Popular Astronomy.

Vol. III. No. 8. APRIL, 1896. Whole No. 28.

THE PLANET MARS.

WM. W. PAYNE.

In our last brief article concerning the planet Mars, it was said that the interesting questions of surface-markings of the planet, its atmosphere, its canals, its oases, its desert regions and color phenomena would receive attention later. To present these topics well, it is necessary to have before the mind a full and clear idea of what has been observed by different astronomers and the meaning of the observations as they understand them. To aid in presenting the results of astronomical work including that of last year it has seemed best to give a large map of the surface of the planet, that this detailed study may be made as explicit as possible for many readers who may not have had access to the original papers of those astronomers who have been foremost and diligent recently in the study of Mars. There are no recent drawings known to us that are so full of detail in regard to the surface study of the planet, as those made by Mr. Lowell and reproduced, in excellent way, in his notable book to which reference in these pages has been frequently made. On this account we have presented, as a frontispiece, his fine map of Mars on Mercator's projection containing a complete numerical designation of 288 references with a list of the names of these markings at the end of this article. Those who have read somewhat of the telescopic work of Mr. Lowell, Professor Pickering and Mr. Douglass, will know that they divide the objects seen on the surface of Mars into three classes and call them "regions," "canals," and "oases."

In our numerical list we have designated the class to which each object belongs by its initial letter after it, so that the list becomes a complete index for ready reference. Observers will be likely to use such a map by putting it into their observing books having the columns of the index of names pasted on the margins of the map. Then any object under study can be readily found and time saved in identifying many markings that will appear to most observers unfamiliar, at times, though they may have seen them before.

The regions, so-called, are considerable tracts of surface, similar in kind. They are either dark, bluish-green in color, or reddish-ochre, and together they form a kind of back ground on which the canals and oases appear in great number between latitudes 40° north and 70° south. The canals are represented by the fine dark lines, and the oases are the round spots seen at the intersections of the canals at many points. The color of the light and dark regions is not attempted in the map, for the tints, or varying hues, would be exceeding hard to get by any means of engraving accessible to ordinary publishers. Some difference in shading is noticeable in the dark areas and this is intended. In regard to the canals it is also noticeable that they always begin and end in oases, or in dark regions. Some are double or parallel and some are found in the dark regions themselves. So far there is no doubt but that these things named have been actually seen and repeatedly mapped by competent and trustworthy observers. By the aid of the 16-inch refractor of Goodsell Observatory we have often seen some of these canals, and we have seen, in a few instances, the double or parallel canals in the region of 320° as marked on the map. It is also true that these canals always appear in the same place, year after year; that they are wonderfully straight, averaging about 1,500 miles in length, the greatest measuring the enormous distance of 3,800 miles and that they are significantly narrow considering their great length, actual measure making them to vary in width from ten to thirty miles.

This system of canals appears to be the key by which we are to learn the real condition of things existing on the surface of Mars. Mr. Lowell believes that their straightness, disposition over the surface, curious markings at their terminal points argue that they have been artificially constructed by intelligent beings for the purpose of distributing a scanty supply of water over the desert regions of the planet. He, in common with some other astronomers, holds the opinion that these canals are not of the actual width of twenty or thirty miles, but that what is seen, as fine lines, represents narrow tracts of vegetation with water courses running through them, and that the visibility of the marks, as such, is due to the fact that the vegetation is supported by the water thus systematically distributed. This water seems to be supplied to the canals from the polar snow or ice cap at the time of the Martian year when the polar snows are melting. This is matter of easy observation by the aid of large telescopes and observers are agreed on noticing the relation of these phe-

nomena. When there is summer in the southern hemisphere of Mars, the south polar snows plainly and quite rapidly melt, and show a darkening of the northern limit of the polar snows in all directions from the pole. This is exactly the appearance that we should expect, if the white and glistening polar cap were made up of snow and ice collected in the long cold winter of Mars, and, in the process of melting by the heat of the Sun as the summer season returns to the same regions. Another important thing helps us to decide the character of these canals, and that is the impressive fact that most of the canals become plainly visible during the period when the polar snows are melting, as if the water from this ice and snow readily found its way for thousands of miles through all this net work of ravines spread over the surface of the planet. At other times of the Martian year they are not so visible, and this is as it should be both to maintain the color of the lines, called canals when plainly visible, as well as to suggest a reason why they should not be easily observed when the season of water flow is past, and the hues of vegetation have changed, so as not present a marked contrast in color from that of the regions in which they are. On this point it would be easy to call attention to a number of minor facts pertaining to the canals in the dark regions, the oases and the light regions, as well that support the same view. But we have space now only to add an interesting paragraph or two from an article recently published in a French paper by Camille Flammarion, the noted French astronomer, the translation of which appears in the *Scientific American* of Feb. 29, '96. Flammarion says:

"All those who have had the unspeakable pleasure of traveling in a balloon, and of hovering at a certain height over rivers have remarked that the latter are reduced to a mere thread, but that their course is admirably traced by the verdant valley that they water, the meadows out-lining such course on both sides. One day, at six o'clock in the morning, while I was at an altitude of 8,000 feet above the Rhine at Cologne, I was much surprised at the tenuity of the river, which was scarcely visible as a green thread in the center of its meadow, which, likewise green, was elongated like a ribbon from south to north. I had the same impression one day in passing over Orleans at an altitude of 10,800 feet above the Loire, when the water was even invisible, and it was the bottom of yellow sand that was seen like a central thread of the strip of meadow land. In the canals of Mars, it is also the product of the water that we see; the vegetation and not the canals themselves.

As for the seas, we ask time to reflect until the month of December, when the planet will return to us, in obedience to the laws of attraction, and permit observers to confirm the lines of this new map. If these dark lines really traverse the seas as they do the continents, we shall be led to modify our interpretation and to no longer consider them as stretches of water.

Nevertheless, there is water upon this neighboring globe. The most evident proof of this is in the snow that extends all around the poles as far as to a latitude that corresponds to that of St. Petersburg, and sometimes even to that of Paris, and which, under the rays of the summer Sun, melt almost completely. This melting of the circumpolar snow is much more complete upon Mars than upon the Earth; doubtless because the seasons, which are analogous to ours, are twice as long. None of it remains except at one point—not at the geographical pole, but at the pole of cold, at 210 miles from the former. Whence is this water derived, and what becomes of it?

We know what becomes of it. It fills the canals and is distributed over the entire surface of the continents for the irrigation of the dry land. It never, or scarcely ever, rains upon Mars. Fine weather is perpetual there. There are no clouds, no rains, no springs, no brooks and no rivers. The circulation of the water takes place in an entirely different manner from that in which it does here.

According to these recent observations, the water derived from the melting of the snow in summer gives rise in the first place to the dark spots that we take for seas, in distributing streamlets of water thereupon that supply the fields and meadows, and perhaps the woods, the tone of which varies with the seasons. Then it is sent by the geometrical network of rectilinear canals to the most desert steppes

The series of disks arranged in echelons at the intersections of the canals represent purposely created oases fed by these waters."

Index of Names on the Map of Mars.

Arranged Numerically.

1 Fastigium Aryn r
2 Socratis Promontorium r
3 Sabaeus Sinus r
4 Deucalionis Regio r
5 Pyrrhae Regio r
6 Noachis r
7 Argyre r
8 Oceanus c
9 Protei Regio r
10 Acesines c
11 Hydriacus c
12 Amphrysus c
13 Garrhuenus c
14 Cestrus c
15 Aurorae Sinus r
16 Caicus c
17 Hipparis c
18 Erranoboas c
19 Dargamanes c
20 Margaritifer Sinus r
21 Ochus c
22 Cantabras c
23 Oxia Palus o
24 Oxus c
25 Pallas Lacus o
26 Dardanus c

27 Tempe r
28 Jamuna c
29 Nilokeras c
30 Indus c
31 Pyphasis c
32 Hydaspes c
33 Lucus Feronia o
34 Hydraotes c
35 Hypsas c
36 Ganges c
37 Baetis c
38 Hebe c
39 Nectar c
40 Corax c
41 Maeisia Silva o
42 Chrysas c
43 Agathodaemon c
44 Coprates c
45 Messeis Fons o
46 Fons Juventae o
47 Clitumnus c
48 Ganymede c
49 Chrysorrhoas c
50 Lacus Lunae o
51 Nilus c
52 Labeatis Lacus o
53 Meroe o
54 Amystis c
55 Catarrhactes c
56 Uranius c
57 Bactrus c
58 Hippocrene Fons o
59 Acherusia Palus o
60 Cyane Fons o
61 Anapus c
62 Artanes c
63 Glacus c
64 Clodianus c
65 Ceraunius o
66 Palamnus c
67 Fortunae c
68 Iris c
69 Mapharitis o
70 Halys c
71 Tithonius Lacus o
72 Tithonius c
73 Avus c
74 Eosphorus c
75 Lerne o
76 Aesis c
77 Daemon c
78 Lacus Phoenicis o
79 Araxes c
80 Jaxartes c
81 Maeander c
82 Phasis c
83 Gallinaria Silva o
84 Acampsis c
85 Solis Lacus o
86 Bathys c
87 Ambrosia c
88 Ogygsis Regio r
89 Surius c
90 Acis c
91 Cyrus c
92 Thyle I. r
93 Drahonus c
94 Cayster c
95 Isis c
96 Astrae Lacus o
97 Malva c
98 Benacus Lacus o
99 Mogrus c
100 Aonius Sinus r
101 Herculis Colhmnae c
102 Hyscus c
103 Memnonia r
104 Erymnis c
105 Gorgon c
106 Medusa c
107 Elison c
108 Parcae c
109 Aganippe Fons o
110 Ulysses c
111 Sirenius c
112 Thermodon c
113 Nodus Gordii o
114 Eumenides c
115 Arduenna o
116 Hercynia Silva o
117 Arsine o
118 Mareotis o
119 Achana c
120 Biblis Fons o
121 Pyriphlegethon c
122 Gigas c
123 Bandusiae Fons o
124 Ferentinae Eucas o
125 Titan c
126 Trinythios o
127 Medus c
128 Alcyonia o
129 Brontes c
130 Steropes c
131 Arachoti Fons o
132 Nitriae o
133 Thyanis c
134 Augila o
135 Neda c
136 Ammonium o
137 Utopia o
138 Lucus Maricae o
139 Liris c
140 Eurymedon c
141 Erinaeus c
142 Evenus c
143 Belus c
144 Arges c
145 Gyes c
146 Castalia Fons o
147 Hibe o
148 Axon c
149 Orcus c
150 Erebus c
151 Hypelaeus o
152 Propontis o
153 Hades c
154 Trivium Charontis o
155 Laestrygon c
156 Atax c
157 Tartarus c
158 Aquae Apollinares o
159 Bautis c
160 Cophen c
161 Antaeus c
162 Axius c
163 Avernus c
164 Cyaneus c
165 Mare Cimmerium r
166 Leontes c
167 Nestus c
168 Atlantis r
169 Padargus c
170 Harpasus c
171 Heratemis c
172 Digentia c
173 Mare Sirenum r
174 Simois c
175 Psychrus c
176 Mare Chronium r
177 Thyle II r
178 Scamander c
179 Gaesus c
180 Opharus c
181 Helisson c
182 Chaboras c
183 Nereides c
184 Chretes c
185 Lucus Angitiae o
186 Cerberus c
187 Clepsydra Fons o
188 Nymphaeus c
189 Cambyses c
190 Lucrinus Lacus o
191 Pactolus c
192 Aethiops c
193 Eunostos c
194 Elysium r
195 Aponi Fons o
196 Styx c
197 Galaxias c
198 Boreas c
199 Achelous c
200 Aquae Calidae o
201 Boreosyrtis c
202 Lethes c
203 Amenthes c
204 Astapus c
205 Isidis Regio r
206 Nepenthes c
207 Libya r
208 Triton c
209 Syrtis Parva r
210 Mare Tyrrhenum r
211 Hesperia r
212 Cinyphus c
213 Eurypus c
214 Flevo Lacus o
215 Galaesus c
216 Hesperidum Lacus o
217 Cynia Lacus o
218 Cephissus c

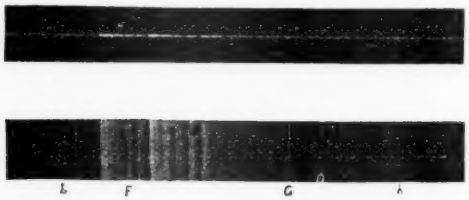
219 Xanthus c
220 Rha c
221 Centrites c
222 Achates c
223 Sesamus c
224 Athesis c
225 Lemuria r
226 Erymanthus c
227 Hylias c
228 Tedanius c
229 Hadriaticum Mare r
230 Orosines c
231 Hippus c
232 Carpis c
233 Syrtis Major r
234 Hyctanis c
235 Dosaron c
236 Japygia r
237 Solis Promontorium r
238 Acolus c
239 Casuentus c
240 Hammonis Cornu r
241 Typhon c
242 Anubis c
243 Asopus c
244 Arosis c
245 Astaboras c
246 Nilosyrtis c
247 Phison c
248 Sirbonis Lacus o
249 Hipponitis Palus o
250 Arsanias c
251 Protonilus c
252 Lacus Ismenius o
253 Euphrates c
254 Sitacus c
255 Orontes c
256 Eulaeus c
257 Labotas c
258 Daradax c
259 Solis Fons o
260 Daix c
261 Hiddekel c
262 Arethusa Fons o
263 Margus c
264 Deuteronilus c
265 Serapium o
266 Gihon c
267 Xisuthri r
268 Edom Promontorium r
269 Neudrus c
270 Magon c
271 Acalandrus c
272 Hyllus c
273 Alpheus c
274 Peneus c
275 Hellas r
276 Tyndis c
277 Oenotria r
278 Arsia Silva o
279 Palicorum Lacus o
280 Nessonis Lacus o
281 Lausonius Lacue o
282 Nuba Lacus o
283 Mare Icarium r
284 Acheron c
285 Mare Erythraeum r
286 Ophir r
287 Ausonia R
288 Daphne o

THE SPECTRUM OF MIRA (*o* CETI.)

H. C. WILSON.

FOR POPULAR ASTRONOMY.

The cut which accompanies this note was prepared from a photograph taken at Goodsell Observatory Feb. 7, 1896, when the variable star Mira was about at its maximum for this year. The photograph was taken with the 16-inch equatorial and spec-



THE SPECTRUM OF MIRA, *o* CETI.

Photographed at Goodsell Observatory, Feb. 7, 1896.

troscope with one 60° flint-glass prism. A narrow slit was used and the exposure given was 50^m; but as the brightest part of the star image was carried off the slit by refraction and had to be re-adjusted every few minutes, the actual exposure was probably

less than half an hour. The plate exposed was a Seed Gilt Edge, sensitometer No. 27, and it was developed with hydrochinon and potassium hydrate.

On the original negative the flutings contain many distinct fine lines and the impression given is that they are made up of lines, many of them so close together as to be inseparable on the scale of the plate. The lines *G* and *h*, which are undoubtedly due to hydrogen, are much sharper and brighter than any of the others in the spectrum. The *F* line, on the other hand, which is also a hydrogen line, occurs in the midst of a bright fluting, where it is not especially distinguished from the others, and it is certainly not so sharply defined or so bright as the *G* or *h* lines.

The visual spectrum was much brighter in the red and green than in the region shown upon the photograph, but, although that portion all fell upon the exposed plate, it made no impression. The appearance to the eye, without any cylindrical lens to widen the spectrum, was very much like that represented in the upper of the two cuts with of course the brilliant colors added. The contrast between the bright flutings and the dark spaces renders the spectrum a very beautiful one.

In order to lengthen the lines as shown in the lower cut, a positive of the original negative was made. This positive, covered by a dark mat with a narrow slit running lengthwise of the spectrum, was moved by clockwork in front of a camera while the exposure was being made. The lines were thus drawn out to any desired length. At the same time the spectrum was enlarged to twice the scale of the original.

This method is open to the objection that, if the plate is very coarse-grained, the grains are apt to be drawn out into false lines. These last are, however, very faint and in the present case have all been printed out in the reproduction with the exception of one. The exception is the sharp line to the right of the letter *b*, and was produced by a pin hole in the positive. It was not noticed until too late to be corrected.

Those familiar with the Fraunhofer lines of the solar spectrum will understand by the letters on the cut, that the region of the spectrum shown is chiefly in the blue and violet. The *b* group of lines is in the green, *F* at the beginning of the blue, *G* is dark blue and *h* is in the middle of the violet color.

ASTRONOMICAL WORK OF DR. W. L. ELKIN.*

With reference to Dr. Elkin's work, Dr. Chandler said:

One of my classmates once told me that he had just been reading Hamilton's treatise on Quarternions. "Why did you waste your time like that?" I asked; "you could not have understood a word of it." I have always admired the frankness and fine enthusiasm of his answer to this rather brutal question: "I admit that," he said, "but I did it as an humble tribute to Hamilton's genius."

It is a feeling akin to this which has led me to select as a topic Dr. Elkin's astronomical achievements. In one way it is as unsuitable for popular presentation as is that of the genius of this age, Dr. George W. Hill, in celestial mechanics. The work of each is of the very highest of its type. Both names belong to that small and most select class which any discriminative critic must include in an account of the contributions of the highest class made by Americans to the astronomy of the nineteenth century. Yet the works of both partake, each in its way, of that purely technical character which makes a descriptive analysis of them, for the purpose of securing for them an adequate and intelligent popular appreciation, a difficult task. It is for this reason that work like Dr. Elkin's so little appears in popular books, magazine and newspaper articles. It contains no theatrical or sensational element. It requires painstaking study on the part of the writer and patient attention on that of the reader. Thus by this easy and rather shiftless avoidance of intellectual effort, those who take a general interest in science lose a most important part of the current history of advance in astronomy.

It is to supply this defect, in this particular direction and for this audience at least, that I have chosen the subject for tonight. With a few words, by way of premise, in regard to Dr. Elkin's personal history, I will then proceed to convey an idea of the general nature of his researches, and afterwards to a somewhat particular account of them and of the interesting instrumental means by which they have been accomplished. The subject is so bound up with the general history of progress in what is called the astronomy of precision, that it is difficult to do this within moderate limits of space, and at the same time give an intelligible impression: but I will endeavor not to go to far afield.

* Abstract of paper presented recently by Dr. S. C. Chandler before the meeting of the Boston Scientific Society, substantially as printed by Mr. Ritchie in the Boston Commonwealth except for minor changes made by Mr. Chandler in copy for this publication.

Dr. Elkin, who is a southerner by birth, completed his astronomical education at Strassburg, as a student under one of the foremost astronomers of Germany, Dr. Winnecke. After the completion of his inaugural dissertation, on the orbit and parallax of Alpha Centauri, he had the good fortune to fall in with Dr. Gill, who had just purchased for the Observatory at the Cape of Good Hope a heliometer, which he proposed to devote to a determination of the distance of important southern stars. His keen desire to participate in this work led to an arrangement between them by which he went to the Cape, where he shared the labor of this most important undertaking with Gill, for more than two years, until its completion. This work was done without remuneration, as his personal contribution, not only scientifically but pecuniarily, was from first to last purely a labor of love. Returning to his native land he was naturally attracted to the Observatory of Yale College, which, under the enlightened directorship of Professor Newton, had obtained a Repsold Heliometer, undoubtedly the finest in existence today, embodying in its construction all the knowledge and the ripest experience of the most competent astronomers and mechanicians of the day. So beautiful an instrument deserved and required, both in its proper handling and the development of its results, that it should be intrusted only to an astronomer who possessed a native genius for that kind of work, but the high technical skill which comes only with especial training for it, as well as the refined habits and thorough astronomical knowledge, without which such a tool would be of a little more real service than a cart-wheel and a gun-barrel. Such a conjunction is a rare one. In this case the opportunity found the man, and the man the opportunity and the happy combination has resulted in the inestimable gain to American astronomy, of which I now try to give an appreciative if inadequate account.

I must first devote some attention to the instrumental means and afterwards to the special problems and investigations to which Dr. Elkin has applied them with such distinguished success.

The ground can be very quickly cleared for what is to be said to-night, by saying that all instruments for the precise measurement of celestial positions may be divided into two broad and distinct classes; first, those required for determining the relative positions of objects situated in widely different parts of the sky; secondly, for doing this for stars comparatively near together, generally in the same field of view of the telescope. It is with the latter only with which we have here to deal: they are denoted by

the name of micrometric measures. When these distances are exceedingly small, as for instance, with the double stars, and the dimensions of the planets, several very old devices, and some newer ones, are still in use, and have been brought to a high stage of efficiency, such as the filar and various forms of double image micrometer. But there is an extremely important class of problems of astronomical measurement which involve greater distances than these forms of micrometer can conveniently or accurately deal with. Such are the diameters of the Sun and Moon and the larger stellar clusters. It was the necessity so arising which gave birth to the heliometer. Dolland, in 1754, conceived the daring idea of splitting an object-glass diametrically in two. When the optical centers of the two parts coincide, a single image of the star results, the same as if no division had been made; but if the two portions be slid along each other, each will form a separate image, and the amount of the separation, if measured, gives their distance. Sixty years later Fraunhofer and Bessel, on this foundation of Dolland's, practically created and developed the instrument as we now know it, the latter by his experience in its application to some of the most important astronomical uses for which we now value it. His example and influence in this direction led other astronomers to make its application and development the subject of the most exhaustive study: so that it stands today as the highest representation, as a work of art, of the science of precise astronomical measurement.

The remainder of Dr. Chandler's paper concerned itself with the work which has been done by Dr. Elkin. His work was begun by the measurement of parallax of important southern stars with Dr. Gill, a department in which the most delicate measurements known to astronomy are necessary, with every precaution obligatory to eliminate sources of error. Work of this character involves measurements within a twenty-thousandth of an inch for single observations, or one one-hundred thousandth of an inch, as the error of a combination of several observations. The work is therefore an exceedingly great tax upon both skill and endurance of the observer, and progress is necessarily very slow. A limit of not above two hundred and fifty sets of measures in a working year is exhaustive to the astronomer.

On his arrival at New Haven Dr. Elkin continued the work on parallax and has determined this with reference to every first magnitude star visible in the northern heavens. He has gone on to attack a still more important problem, in the investigation of the parallaxes of about one hundred stars having considerable proper motion.

The methods of work were described in detail with such account of the New Haven instrument as was necessary to show the nature of its operation. The diameter of the Earth's orbit is the base line for measurement of parallax and accordingly observations of the position of the star are taken at intervals of six months. The star is carefully located with reference to its fellows in the sky, four companion stars in four directions being selected for this comparison. The slight difference in position resulted from these measurements is the parallax, and from this may be determined the distance of the star from us.

Of like nature is the problem of the distance of the Sun, and upon this Dr. Elkin has been at work with results which at first were received with caution on account of their apparent smallness but which have since been supported by new determinations in other ways. The close relationships which have been proven between the elements which compose our solar system are such that the exact determination of the distance of any one planet will afford a means of computing all the other dimensions and distances. It was therefore suggested that the observations of some of the asteroids might be of value, and accordingly Dr. Elkin made a series of measures of Sappho and Victoria, with a result as above stated.

In addition of these matters attention has been given at New Haven to the triangulation of some seventy stars in the Pleiades, each of which was independently measured for position at intervals, standard stars outside of the group having been selected for the purpose.

"These different accomplishments," said Dr. Chandler in finishing, "constitute a record of faithful, zealous, and vigorous prosecution of astronomy in its very highest plane, and the presence of such a man as Dr. Elkin in our country gives standing and credit to American astronomy."

ALASKA BOUNDARY SURVEY.*

OTTO J. KLOTZ.

FOR POPULAR ASTRONOMY.

The second distinctive and most important feature of the camera is the attachment of a plano-glass orange screen to the lens. It is screwed to the back of the objective. It is obvious

* Continued from page 353.

that it is desirable to have on the negative not only what we can see, and especially is this true of the distance, but also that distinct and not blurred. Now the negative or sensitive plate, which is analogous to the retina of the eye, is however not sensitive in the same measure to the visual rays as the retina. Visual rays are at the red end of the spectrum and photographic, or actinic at the blue end. A ray of light from the Sun before reaching us suffers partial absorption by the atmosphere which in turn reflects and diffuses light. Hence a reflected ray from a distant point enters the camera in a depleted state, suffering from loss of vigor. However it could still do effective work if it did not meet with the antagonizing energy of the rays—less luminous but more actinic—reflected by the atmosphere, so that the weak imprint of the former is almost completely annihilated by the action of the latter. To overcome the difficulty, or at least to tend towards attaining our end, recourse is had to isochromatic plates and the orange screen above mentioned. The emulsion of these plates is colored for intensifying the action of the yellow rays which reach it from the distant point, and the orange screen for absorbing or cutting off the blue rays entering the camera from the atmosphere. Photographically speaking, we try by means of the orange screen to create a vacuum between us and the distant view to be photographed so that the rays from there, filtered as they are already may have some chance of doing satisfactory work. The blue haze is the enemy—and it is drowned in the artificial yellow sea. For the proper development of the negatives some light is necessary and to which the plate must be insensitive. The isochromatic plates used were made insensitive to red, and hence were developed under red light. The photograph of a red object would therefore print black, that is on the negative would appear blank. The sensitiveness of the plates was confined almost wholly to the yellow part of the spectrum. We are therefore from the conditions surrounding us, obliged in applying photography to topographical purposes, to utilize the yellow rays and cut off the more powerful (photographically) blue rays.

Without the insertion of this screen, much of the work accomplished with the camera would have been impossible, hence its great value.

In such an essentially humid atmosphere as obtains in southeastern Alaska, extra provision had to be made to keep the plates dry, and also for the event of casualties on the water. Hence tin boxes were provided, each holding two dozen glass

plates. These boxes were water tight and had air chambers, so that when containing the plates they would float.

The field operations with the camera are very simple, yet require discretion, and the value of the expert topographer comes into play. Having arrived at a summit station, the transit or camera is first set up, depending on atmospheric conditions. A sketch is made of the horizon, and of the broad features, noting specially peaks or other points read on. As the lens takes in sixty degrees, seven plates will take in the whole horizon and allow a lap for each one, so as to have one or more points common to two photographs for orienting one view from another. As there is no ground glass for seeing the field covered, two diverging lines are cut or scratched on the top of the camera indicating the angle of the lens. Sighting along these one readily sees the limits of the view and thereby can give the proper consecutive pointings. Every station does not require a complete circuit of the horizon. It also happens that the photographs from a peak do not show sufficient of detail of valleys, being hidden by the configuration of the mountain, whereas, by going a short distance—a hundred or so feet from the summit—the desired view is obtained. This is done and the direction and distance of the new position of the camera from the station noted. In plotting on a $\frac{1}{80000}$ scale—that of the original office sheets—such camera station may often be taken as co-incident with the triangulation station.

As the plates are exposed a record is made of the numbers of the plate, the pointing of the camera and the view taken. The time of exposure varies, of course, with the position of the Sun, the state of the atmosphere and the nature of the object. As an aid in estimating the quality of the light each surveyor carried what may be termed an actinometer. It was the size of a large locket and contained a continuous strip of sensitive paper. By pulling out a short piece and noting the time it took to assume a certain tint a fair estimate of the quality of the light would be obtained, and the exposure made accordingly. The exposure ranged from 6 to 40 seconds. It is satisfactory to be able to state that of the 250 dozen plates exposed not a single one proved to be worthless. Some were exposed (from necessity) even when it was raining.

Each party was supplied with several aneroids, one of which was left at camp for continuous reading. A mercurial, Greene, barometer was carried on board the Survey steamer, and with it the aneroids were compared. The aneroids furnished a ready

means of obtaining the approximate height of the mountains climbed. Some of the parties carried thermometers too in their ascents for taking the temperature of the air so that the aneroid reading could be more accurately reduced. The final altitudes of all points, however, rest on the trigonometric determinations and those obtained from the photographs based thereon. From a large number of readings of the aneroid which where comparable with trigonometric heights, it was found that by carefully reading the barometer at ascent and descent, and noting the temperature of the air by a good thermometer (not attached to the aneroid) that the mean will give a fair value say within two per cent of the difference of height of the summit and base or sea. This applies to mountains upwards of five thousand feet in height.

Without going into the details of the office work some of the salient points connected therewith may be mentioned. From the negatives enlargements are made to twice the linear measure, *i. e.* to four times the surface, on bromide paper. The focal length and position of the horizon and principal lines with reference to the comb marks are specially determined by taking a photograph of a large building on which three or more horizontal and vertical angles each are read. Any field photograph in which the azimuth and elevation or depression of a number of points have been taken furnishes the necessary data too, in fact thereby we have a means of checking for contraction or expansion of the paper of the print, as the focal length and horizon line for any camera are constant. The plotting is done on a scale of one in eighty thousand. First the meridians and parallels are projected, then the triangulation is plotted.

Evidently every photograph by itself gives the relative azimuth of every point in it from the pointing of the camera, *i. e.*, from the prolongation of the optical axis of the lens. So that if we measure on the print from the principal line (a vertical approximately in the centre of the view) to the right or left to any point the distance will express the tangent of its azimuth in terms of the focal length as unity. In utilizing the photographs, however, we have nothing to do with angles, but only with their linear measure, and these are all referred to the focal length as constant. If now, from the triangulation, we know the absolute azimuth of one point shown in the print, then we can lay off on the plan the relative azimuth of such point and thereby obtain the pointing of the camera. This now being known, the absolute direction of any point in the photograph immediately fol-

lows. Hence by means of the triangulation lines the photographs are oriented. From what has been just said it follows that a view containing no triangulation point may be oriented, provided it joins and laps one that has been oriented. Obviously for every point that can be recognized as identical on two views from different stations we have the direction from each station, and therefore know its absolute position,—being at the intersection of the two directions. As many points as can thus be recognized, just so many points can be plotted, and their distances known from the station.

In this manner we exhaust all desirable common points on the prints and transfer them to the plan. This eliminates the horizontal element of our perspective; we have next to deal with the vertical element, the one that expresses the topography.

Just as the principal line serves to measure the relative azimuth of any point, so the horizon line, which is drawn on the print between the lateral comb marks, serves to determine the elevation or depression of any point above or below the level of the camera.

Remembering that we now know the position and distance of the point whose height we wish to establish, the simple geometrical relation of similar triangles which subsists between focal length, absolute distance of point from station, and linear measure on print of point above or below horizon line, immediately gives us our fourth term in the proportion, *i. e.*, the linear measure expressive of the elevation of the point, and this measure is converted into feet by applying the ratio on which the map is constructed, that is, the scale. For the purpose of facilitating the graphical solution of similar right angled triangles, a triangular scale printed on card board 11 inches by 27 inches is used. The triangular scale is a large right angled triangle, subdivided by equidistant perpendiculars on the base and by radiating lines from the acute angle. To each point thus determined is written its height above the sea. When a terrene is filled with a sufficient number of established points, the contour lines, 250 feet apart, are drawn. This requires skill, for, with photograph in hand, the expert topographer sketches in details not indicated by the plotted points.

Points, as the shore line of lakes, islands and rivers, lying the same horizontal plane are readily plotted from a single photograph taken from an elevation of known height. The altitude must be sufficiently great so that the angle of depression is not too small. From an elevation of 3,000 feet above a horizontal

plane one can plot without difficulty points on it distant fully three miles.

In its broad outlires the plotting of photographs is nothing more than a continual graphical solution of right angled triangles.

We have taken some 3,000 photographs, and have covered, approximately, 14,000 square miles, with our photographic work.

The photo-topographic work, although perfection is not claimed for it, will undoubtedly displace the older methods of survey for highly mountainous areas, for its superiority over them has now been permanently established.

View No. 3 is from a station, altitude 4,319 ft., on the west side of the northern part of Thomas Bay and looking easterly across the Baird Glacier, showing its terminal, which almost reaches the sea—shown on the right hand. The view well illustrates the "flaw" of a glacier, which shows (the ice being a brittle and not a viscous mass) all the characteristics of the behavior of water, such as, the greatest velocity towards the center, the thread, eddies and falls.

From photographs taken at intervals covering several months and from the same stations on the fluvio-glacial deposit lying between the ice front and the sea I determined the rate of motion of the front of this glacier to be about one foot per day during the period of observation. It is believed that this is the first application of the camera for determining the rate of motion of glaciers.

View No. 4, shows that all in Alaska is not ice and snow and rock, but that along the sea shore the vegetation is rank; ferns, brakes, mosses, the Devil's club and other forms vying with each other in their luxuriant growth for supremacy. The particular locality represented is in the south side and near the entrance of Bradfield Canal. Other illustrations explain themselves.

THE VARIABLE STAR 8598 U PEGASI.

PAUL S. YENDELL.

For Popular Astronomy.

One of the most interesting cases of variability which have recently been discovered is that of U Pegasi, of which a short notice was published in the Popular Astronomy for December, 1895, by Mr. John A. Parkhurst.

In September, 1894, in the course of a correspondence with Dr. Chandler relating to certain suspected variables, I received an intimation from him that he strongly suspected that he had found a variable of the Algol-type, the second found by him during that season (the first being Z Herculis).

His next letter, dated Sept. 23, contained the means of identifying the star, and the suggestion that its period might possibly be about 2.06 days.

PLATE XIV.

Alaska Boundary Survey.

No. 3. The Baird Glacier.

Reproduction of Photograph by the Canadian Commission Officers. See page 400.

No. 4. At Sea Level.

Reproduction of Photograph by the Canadian Commission Officers. See page 400.

PLATE XV.

Alaskan Boundary Survey.

No. 5. In Frederick Sound.

Reproduction of Photograph by the Canadian Commission Officers.

No. 6. Bradfield Canal.

Reproduction of Photograph by the Canadian Commission Officers.

PLATE XVI.

The Alaska Boundary Survey.

No. 7. The Devil's Slide. Lynn Canal.

Reproduction of Photograph by the Canadian Commission Officers.

Parliament Building.—Ottawa.

Reproduction of Photograph by the Canadian Commission Officers.

I at once began observations upon the star, and on October 18 and 19 had the good fortune to observe minima, followed by others on October 27 and November 3. Observations of well defined increases and decreases were also observed on various dates, until 1896, January 24. These observations could not all be accounted for by a period of $2^d.06$, and a careful examination and discussion of all the data resulted in the conviction that the two-day period was inadmissible, and that the real period was almost certainly $\frac{2^d.06}{n}$, the most probable value of n being 3, that is to say, a period of $0^d.69 \pm$.

As the star had not been followed at any one time longer than was considered enough to fix the date of minimum, and the duration of the light-changes, no doubt was entertained either by Chandler or myself that its variability was of the Algol-type.

Upon communicating my conclusions respecting the star's period to Dr. Chandler they were strongly contested by him, on the ground that continuous observation during the season excluded the supposition of any shorter period than that suggested by him; on the other hand, I was by no means prepared to admit that so large a proportion of my observations had been grossly in error; and in default of further evidence, there the matter rested.

As soon as it was possible to observe the star in the summer of 1895, I began to watch it, and obtained minima on July 30, and on September 13 and 15; these, being compatible with the long period, were indecisive; but a very carefully and sharply-determined minimum on the evening of September 24, was again entirely discordant.

A careful re-reduction and discussion of all my observed minima was then made, with the result, that the period most satisfactorily accounting for my observations was $0^d.69$, and I was entirely satisfied that the actual period of the star was not far from this value. The minimum first observed, however, of 1894, September 18, was still sharply discordant, and was not accounted for by either period.

On communicating the results of this discussion to Dr. Chandler, then in the country, he still continued to hesitate, as my observations and deductions seemed incompatibile with his own observations of the previous year.

In view, however, of the inadequacy of the optical means available to him at that time, he reserved his judgment.

On arriving at his home in October he at once began observa-

tions on the star with a sufficient telescope, and on October 21, I received a note from him which informed me of two minima observed by him on October 18 and 19 (which minima I had also observed) and with characteristic open-mindedness he writes in the same note, "I no longer have any doubts of the subdivision of the period as I originally thought it was (2.06 ±) by three, as you have proved."

Dr. Chandler continued his observations until he had secured evidence confirmatory of a suspicion which had been suggested by his observations of October 18, that the period was still further subdivided, and that the star as is now fully proved, was not an Algol-type star, but a variable of a new and peculiar type with a period of $5^h\ 31^m\ 9^s$, the shortest yet known.

His announcement of these facts, and my confirmation, in the *Astronomical Journal*, Vol. XV, pp. 181 and 191 respectively, followed immediately.

This period accounts for my own minimum of 1894, September 18, and shows how important it is not to disregard the indications of observations apparently hopelessly discordant. The residual from the seventeen-hour period was in this case $5^h\ 34^m$, within three minutes of the actual period. Thus I had the key to the whole enigma in my hands from the first.

Both Chandler and myself at once proved by actual observation that the period was not further subdivided. My observations were continued until the end of the year, and were completely confirmatory of Chandler's discovery; the observed times have already been published in Vols. XV and XVI of the *Astronomical Journal*.

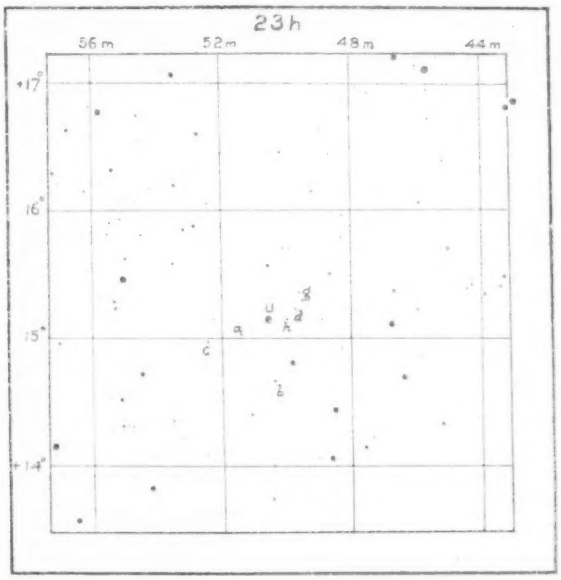
Upon a preliminary examination of the star's light-curve, Dr. Chandler concludes that, as above stated, it is of a new type of variability, its time of increase being at least equal to that of its decrease, if not greater. All the stars of the type of η Aquilæ and δ Cephei increase more rapidly than they decrease, the proportions varying in different cases. So far as I can infer from my own observations, the proportion of increase to decrease in the present case is very variable, so that the light curve is not constant, at least in successive phases. The observations, however, are not yet numerous or continuous enough to decide this matter and the whole question must rest until we have at least one more season's observations available.

Though Dr. Chandler's period, above stated, is not more than a single second in error, the individual maxima and minima depart widely from the computed times, frequently showing residu-

als of more than an hour. The suggestion of observational errors as an explanation of these anomalies is inadmissible, as the phases, especially the minima, are very sharply defined, and allow of very accurate determination; in three minima which Dr. Chandler and I observed simultaneously, the mean difference in our determination is three minutes. No suggestion of any explanation of the irregularities indicated by these anomalies is yet possible; and at least one more year's work is necessary before any will be possible.

It is very much to be desired that observers who have sufficient optical means should pay especial attention to this star. Its changes are continuous, and even a single hour's observations show a change, while three hours of continuous work can scarcely fail of determining one phase, and six or seven hours may give two maxima or minima, with the intervening phase. No ephemeris is necessary; in fact, while the observations are in progress, it is much better dispensed with.

A four-inch refractor will command the star's entire light-range $8^m.8$ to $9^m.8$, according to Chandler's observations, and an aperture of two inches will be sufficient for the maxima.



8598 U Pegasi.

The subjoined chart, which is a copy of my own observing-

chart, will give all the comparison-stars necessary. Those whose telescopes are not fitted with circles may find the star by putting γ Pegasi in the southern edge of the field, and sweeping westward about four degrees.

Its position for 1900 is

$$\alpha \ 23^h \ 52^m \ 53^s \quad \delta + 15^\circ \ 23'.9$$

The comparison-stars, with my light-scale and magnitudes, are

	DM	(1855)			Y		
	°	h	m	s	°	′	M	M	Light
$a =$	+ 15	4916	α 23	51	28.0	δ + 15	2.2	8.8	8.80	20.0
$b =$	14	5078		50	20.9	14	39.6	9.3	9.10	15.7
$c =$	14	5080		52	25.4		58.5	9.5	9.28	13.0
$g =$	15	4909		49	35.1	15	21.2	9.5	9.54	9.1
$d =$	15	4910		49	31.4		13.6	9.5	9.60	8.4
$h =$	15	4912		49	58.6		9.3	9.5	9.79	5.6

It is very important to secure as continuous a series of observed phases as possible, and it is therefore hoped that a number of observers will watch this star. From the middle of May the star will be observable as early as three A. M., and the conditions are such that two hours' work on each of three successive mornings must result in securing at least one phase.

The methods and precautions employed in observing the Algol-type stars will be in order in this case, and as every night is sure to include one or two entire periods, the danger of knowing when the phases should occur may be wholly avoided.

DORCHESTER, 1896, February 22.

OBSERVATIONS OF SHORT-PERIOD VARIABLE STARS.

W. E. SPERRA.

FOR POPULAR ASTRONOMY.

In view of the fact that Mr. P. S. Yendell has been putting forth earnest effort through the pages of this Journal to forward the observation of the class of variable stars, known as short-period stars, it was suggested to the writer by Mr. J. A. Parkhurst—who hitherto has been publishing in these pages the results of my observations in this line of work—that it would be interesting and appropriate that some results from the observation of this class of variables be shown at length.

At different intervals during the past year, the writer had under observation six of the twenty known stars of this class

which are within reach of northern observers. Some of the results of this work is given below.

Certainly no class of variable stars yield so great results for the little effort put forth in their observation, as do these stars. A few minutes devoted each clear evening to their observation for a week or two suffices to determine at least one light phase, and in the case of the majority of the stars is sufficient to follow them through several consecutive periods. Now then, contrast this with the time required to observe one phase of the long-period stars, or even with the time required to observe a minimum of the "Algol" stars, in these latter stars four or five hours and in some cases a whole night is required to successfully determine the time of minimum, while in the case of the long-period stars several month's observations must elapse before we can be certain of any fruit of our work. As an example of this latter case take my minimum of 5194 V Bootis for 1895, July 29, the observations to determine this phase commenced April 10 and continued until Oct. 9, a period of six months, within which time forty-eight individual observations were obtained.

Then again, this is not the only consideration that should commend their observation to those interested in this work; the instrumental aid required is but meagre, an opera or field glass sufficing to observe all but three or four stars of this class, in fact they are the only instruments that can be advantageously used. While ζ Geminorum, β Lyræ, η Aquilæ and δ Cephei are readily followed with the naked eye.

Some may think, as I did before observing any of them, that because their range in light variation is comparatively small, amounting in some cases to only a fraction of a magnitude, that therefore they are difficult of observation; but this is not true, they are as easy to observe as are the long-period stars whose range is many times greater. This arises from the fact that their change is more rapid, and with several exceptions they are uniformly white or at most yellow in color, while most of the long-period stars have some admixture of red, thereby rendering comparison with whiter companions more difficult. Lastly, while the observations of these stars are exceedingly interesting, and are valuable to science, they give a training to the observer that is of value in the observation of new or difficult long-period or Algol stars.

2279. T Monocerotis.

This star was observed twenty-one times from 1895, March 18

to May 1, yielding two maxima and one minimum as follows: Max. March 28.0, 6.1 mag.; a minimum April 16.0, 6.8 mag.; and another maximum April 25.2, 6.1 mag. This is a very interesting star to observe, the fall is considerably slow, while the rise is about three times as rapid. It has the longest period of this class of stars. For more regarding this star and the others mentioned below, see articles in Vol II of this Journal, by Mr. P. S. Yendell.

4805. W Virginis.

Twenty-two observations between 1895, May 12 and June 24, yield three maxima, being an average of seven observations to each maxima. The resulting times are May 17.0, mag. 8.7; June 1.7, mag. 8.9; and June 19.3, mag. 8.6. The rise and the fall of this star are accomplished in nearly equal periods. But owing to its faintness at minimum, a telescope of not less than 3-inches aperture is required in dealing with it.

6636. U Sagittari.

Here we have a star whose complete cycle of change is accomplished in a little less than a week. From 7.0 magnitude at maximum, in four days it falls to a minimum of 8.3 mag., then in three more days it rises to maximum. It is therefore very interesting to watch. Owing to its position in the midst of a small cluster of stars, it also requires a telescope to observe it. This is one of the two exceptional stars of its class as to color, its redness is assigned in Dr. Chandler's Second Catalogue as 3.7, which signifies that it is nearly full orange red in color. Twenty-six observations yield by mean light curve (published in the articles alluded to above) nine phases as follows:

				No. Obs.	Ephemeris Date.	
1895	May	29.20	Max.	2	May	29.47
	June	18.48	Max.	2	June	18.70
		22.82	Min.	2		22.48
		26.05	Max.	2		25.45
	July	17.28	Max.	2	July	15.68
	Aug.	8.04	Min.	2	Aug.	8.69
		11.60	Max.	3		11.66
		16.06	Min.	2		15.43
		22.84	Min.	3		22.16

6758. β Lyræ.

Interest in observing this star lies in the fact of the unique character of its light variation, which presents two distinct maxima and minima in each period of less than thirteen days. But as the principal minimum is the only point of reference in its light curve, this only need be observed; observations to determine this phase

should commence about three days before, and extend the same length of time after the date given in the monthly ephemerides of these stars in this journal. My minima by mean curve from naked eye observations are 1895 July 25.94 from two observations; August 7.78, two observations and Sept. 2.96 from three observations.

7124. η Aquilæ.

This is another star that accomplishes its variation from 3.5 mag. at maximum to 4.7 mag. at minimum and back again to maximum in about a week's time. The rise is quite rapid, being accomplished in considerable less than three days. Compare the amount of rise in this star with that of the long-period variables in the same time, for an illustration of the greater interest attending the observation of these stars. I have twenty-six naked eye observations of this star between 1895 Aug. 13 to Nov. 15, and the result is six maxima.

			No. Obs.	Ephemeris Date.	
1895	Aug	13.99	2	Aug.	14.78
		22.19	3		21.96
		29 24	2		29.14
	Sept.	13.00	2	Sept.	12.49
		19 91	4		19.66
	Oct.	18.52	3	Oct.	18.37

This last maximum was also obtained by the graphic method of reduction from five observations as Oct. 18.56.

7437. X Cygni.

The following ten consecutive phases of this star from only fifty observations, extending over a period of less than three months, certainly emphasizes the fact that many fold more fruit results from the little effort put forth in the observation of these stars, than that resulting from the same amount of work on the long-period stars. As the period of this star is some over sixteen days, the reduction is by the usual graphic method. The light curve of this star is not constant in different periods.

				Mag.	Ephemeris Date.	
1895	June	1.8	Min.	6 7	June	1.83
		7.2	Max.	6.3		8.63
		18.1	Min.	6.6		18.22
		24.5	Max.	6.3		25.02
	July	4.4	Min.	6.6	July	4.61
		10.1	Max.	6.3		11.41
		18.9	Min.	6.7		21.00
		26.4	Max.	6.3		27.80
	Aug.	7 9	Min.	6.7	Aug.	6.39
		12.8	Max.	6.2		13.19

Randolph, Ohio, March 4, 1896.

GALILEO'S WORK ON SATURN'S RINGS.—A HISTORICAL CORRECTION.*

E. A. PARTRIDGE AND H. C. WHITAKER.

In the spring of 1609, Galileo made his first telescope and immediately began his very extensive observations of celestial objects. In march, 1610, he published his Sydereus Nuncius, containing a statement of his discoveries up to the time of the publication. He counted forty stars in the Pleiades, showed that the Milky Way was composed of innumerable stars instead of being a nebulous cloud, and gave a description of the phenomena of the four satellites of Jupiter.

It was stated by Arago† that at the end of this Sydereus Nuncius, Galileo wrote his famous logogriph with reference to the appearance of Saturn; this however is not the case. In this connection, it may be said that Arago's treatment of Galileo has been shown to be grossly unfair by the editor of Galileo's collected works, Eugenio Alberi. The importance of this is seen from the consideration that Arago's account has been the basis of what has been said of Galileo's astronomical work by most of subsequent writers.

It was not until the 25th of July, 1610, four months after the publication of Sydereus Nuncius, that Galileo saw any peculiarity in Saturn. On the 30th of that month, he sent a letter to Belisario Vinta, Prime Minister to the Grand Duke of Tuscany, in which letter he says,—

"On the 25th instant, in the morning, I commenced to observe Jupiter with his band of Medicean planets, then in the east; and further I discovered another most singular marvel which I desire may be known by Your Highness and held secret by you in order that in the work which I shall print, it may be published by me: but I have wished to give an account of it to Your Most Serene Highness in order that if others hit upon it, they may know that no one has observed it before me; although I am quite sure that no one will see it unless he has his attention called to it. This discovery is that Saturn is not single but a composite of three, which seem to touch each other and never change their relative position and never move among themselves nor change: they are placed in a line parallel to the Zodiac; the one in the mid-

* Extract from paper read before Camden Astronomical Society January 8th, 1896.

† Biographical Notices, Life of Galileo, t. III, 269.

dle being about three times larger than the two lateral ones and being situate in this manner, oOo. In the autumn I will be able to show them to Your Highness, as all the planets being above the horizon, it will be exceedingly convenient to observe them.*"

At about the same time that he sent this letter to Vinta, Galileo announced the discovery in the form of a logogriph

Smaismrmilmepoetaleumibunenugttauiras

to Giuliano dei Medici, who was ambassador from the Grand Duke of Tuscany to the Emperor Rudolph, whose court was at Prague. These statements are made in detail because practically all the works on popular astronomy have neglected the letter to Vinta and, although not following Arago's error about the publication of the logogriph in Sydereus Nuncius, have substituted another one by saying that the logogriph was sent by Galileo to Kepler. Galileo had, at the time of the publication of Sydereus Nuncius, sent a copy of the work to Giuliano dei Medici and Kepler being at Prague as imperial mathematician,† the work was sent by Medici to him; he welcomed it with a commentary on it dedicated to Giuliano dei Medici, completed in a few weeks.

About four months afterward, on the 13th of November, 1610, in a letter to Medici, Galileo sends the correct arrangement of the the letters of the logogriph as follows:

Altissimum planetam tergeminum obseravi. The farthest planet I have observed to be triform.

Galileo then gives the sketch already sent in July to Vinta oOo, and goes on, "but with a telescope of lower power than the greatest, the appearance of Saturn is one star elongated in the form of an olive, thus ⊂⊃. But using a telescope which magnifies more than a thousand times in area, there are seen three distinct globes, which almost touch each other, the distance between them not being greater than a fine obscure thread."‡

In a letter to Galileo dated 17th December, 1610, Padre Clavio says, "Today I wrote to Signor Santini that you have discovered that Saturn is composed of three stars, that is to say that two smaller stars stand one on each side of it. This we have not yet been able to observe. We have only noted with the instrument that Saturn appears oblong in this fashion ⊂⌒⊃."§

* Opere di Galileo, Florence 1842–1856, t. VI, 114. All other references to Opere di Gal. are to this edition.

† Kepleri Opera, t. VIII, 668.

‡ Opere di Gal., t. VI, 126.

§ Opere di Gal., t. VIII, 120.

Evidently Clavio had excellent vision; Huyghens, having a telescope much more powerful, afterward makes much the same sketch.

Answering this letter on the 30th December, 1610, Galileo says,—"Had you a telescope of magnifying power of 1,000 areas, you would see Saturn in this form oOo; I have shown it to people always quite distinctly, so that they had no doubt that they saw it exactly thus. Five months ago, it was seen considerably larger. From that time to now, it was much diminished."*

In a letter, 12th February, 1611, to Fra Sarpi, Galileo, referring to this decrease in size, attributes it to the increasing distance of Saturn from the Earth.†

In a letter to Velser, May, 1612, rather impatiently answering Velser's criticisms on his observations, Galileo states that after a thousand observations at different times, Saturn had always appeared to him thus oOo.‡

Cesi, on 30th November, 1612, evidently referring to a letter from Galileo, in which Galileo probably states that he no longer sees the lateral bodies, says,—"The new appearance of Saturn seems so much the more strange to me from the fact that you have said that the lateral bodies have no motion whatever, nor are subject to any sort of change."§

On the first of December, 1612, Galileo, at the end of a long letter to Velser, says:—"I have already written to you how about three years ago, I discovered to my great astonishment that Saturn was tricorporate, that is,—an aggregate of three stars disposed in a right line parallel to the Equinoctial, of which the middle one was considerably larger than the lateral ones. I believed them to be immovable among themselves, nor was my belief without reason, since having seen them in the first observation so close that they seemed almost to touch and such condition being preserved for more than two years without any change appearing in them, I was forced to believe that they were totally immovable among themselves, because if they were subjected to a very minute motion, it would in such a time be made sensible, either in consequence of this motion to separate or totally unite the three stars; triform, I still saw Saturn this year about the summer solstice; and having stopped observing it for more than two months, since there was no doubt as to its constancy, finally

* Opere di Gal., t. VI, 130.]
‡ Opere di Gal., t. VI, 141.
† Opere di Gal , t. III, 396.
§ Opere di Gal , t. VIII, 244.

I turned to observe it recently; I found it solitary, without the presence of the accompanying stars and in the highest degree round and terminated like Jupiter, and thus it continues to remain.

"Now what is to be said concerning such a strange metamorphosis? Have the two minor stars been consumed after the manner of solar spots? Have they disappeared and suddenly fled? Has Saturn devoured his own sons? Or, was the appearance illusion and fraud, with which the glasses have for so long a time deceived me and so many others who have observed it many times with me? Has the time come to revive the now almost withered hope in those, who, guided by more profound contemplations, have seen all the new observations to be fallacies, which could not in any way stand? I do not know what to say with certainty in a case so strange, unlooked for and novel. The shortness of the time, the phenomenon without parallel, the weakness of the reasoning power and the fear of erring render me greatly confused.

"But I may be for once permitted to use a little temerity, which you will pardon so much the more benignly as I confess it to be so, and I protest that I do not intend to register it for prediction among propositions dependent on positive principles and secure conclusions, but only as some of my conjectures which perhaps I will make evident when they will require me either to show the excusable probability of the opinions to which I now incline or to establish the certainty of the assumed conclusions when my thought agrees with the truth.

"The propositions are these: The two minor Saturnian stars, which at present are concealed, will perhaps show themselves a little for two months about the summer solstice of the next year, 1613, and then will disappear remaining concealed till toward the winter solstice of 1614; about which time it may happen that again for some months they may make some showing, turning then anew to disappear till almost the next following winter; at which time, I believe, indeed with greater resoluteness, that they will appear and will no more disappear; if not that in the following summer solstice, which will be of the year 1615, they will tend somewhat to disappear, but I do not believe, however, that they will disappear completely, but turning shortly afterward to reveal themselves, we will see them distinctly and more than ever lucid and large; and I resolutely dare to say that we will see them for many years without any interruption. Although of the return I do not doubt, I am however, reserved as

to the particular phenomena founded at present merely on probable conjecture, but whether they occur in exactly this manner or in another way, I say to you that this star will yet, and perhaps not less than the horned appearance of Venus, concur in an admirable manner to the harmony of the great Copernican system; to the universal establishment of which, they are seen to be propitious winds to guide us with such shining escort that we are never left to fear darkness and tempests."*

Although written as a single paragraph by Galileo this extract from the letter to Velser has been here put into four paragraphs. Galileo speaks of his observations in the first of these paragraphs; in the second he speaks of his momentary confusion at the disappearance of the rings; he puts himself in the attitude of a supposed opponent of himself and proposes questions from this point of view and these positions he antagonizes in the latter part of the letter; very curiously, practically all of the works on popular astronomy have isolated this very portion of the letter and have taken it to represent Galileo's attitude of mind, both at this time and subsequently. For instance, Arago says: "Galileo directed his telescope on Saturn as soon as circumstances permitted him.† The feebleness of his instrument threw him into great perplexity. A letter to the Grand Duke of Tuscany‡ shows us that Saturn seemed to him tricorporate."

"A time came (1612) when the two lateral stars were no longer visible to Galileo. The planet then seemed to him perfectly round. It appears that this circumstance discouraged him in the highest degree. He even went so far as to think that in all his anterior observations the lenses of his telescopes had deceived him and had transformed that which was only an illusion into a real object. One can see the expression of this discouragement in his letter to Velser of 1612. That which is certain is that after this epoch, Galileo no more occupied himself with Saturn."§

Especial attention is called to the last sentence of this extract.

Ball‖ quotes this second paragraph of the extract of the letter to Velser as the last word of Galileo; Proctor, Flammarion, Young and others are a unit in saying that Galileo's great perplexity (!) led him to abandon all further observations. Newcomb makes the same statement in his Popular Astronomy, but

* Opere di Gal., t. III, 506.

† It was about fifteen months after he had made his telescope.

‡ There is no letter to the Grand Duke on this subject in the collected works of Galileo. Arago probably refers to the letter to Vinta.

§ *Astronomie Populaire*, t. IV, page 442.

‖ Story of the Heavens, page 237.

with his characteristic caution, says the authority for it is unknown to him.

In the third paragraph of the extract Galileo excuses himself for venturing to predict the re appearance of the two bodies; certainly not betraying the great discouragement spoken of by Arago.

The prediction which he actually makes in the fourth paragraph of the extract may be dismissed by saying that although the predicted sequences of re-appearance and disappearance correspond with the facts, yet the periods were wrong. We are unable to conjecture the hypothesis of Galileo, but almost certainly it could not have been that the disappearance and re-appearance of the bodies was largely a question of perspective. Whatever his hypothesis, and whatever his state of mind, whether of expectancy or discouragement, *certain it is that he did not cease his observations on Saturn.*

On the 3rd of September, 1616, four years after the disappearance of the rings, two letters were sent to him, one by Cesi,* the other by Faber.† Both refer to a new appearance of Saturn. This reference is certainly to observations made by Galileo himself about the end of August, 1616. His observations were recorded in a journal marked Codex Observationum and give this sketch, which along with store accounts, was dated 1616.‡

On the 4th of August, 1640, twenty-four years later, we have a letter from Castelli, a former pupil of Galileo, studying under him at the same time as Torricelli. Castelli informs Galileo that an observation of Saturn revealed the triform appearance the same as in 1610 to 1612.§ It will be noticed that, counting from 1610, Saturn had just completed a revolution. This letter was answered by Galileo on the 28th of August, 1640, and his answer was published in a Padua edition of his works in 1744. Arago's Astronomie Populaire was published more than a century later.

Galileo says: "The first sight that I had of Saturn was of three round stars disposed in a straight line from east to west,—that in the middle considerably larger than the two lateral ones; such I continued to see it for some months, and having then stopped observing it for some other months, I turned to look at it and found it solitary, that is the large star in the middle was alone. Marveling at this, I pondered how such a change could

* Opere di Gal., VIII, 389.
† Opere di Gal., VIII, 390.
‡ Opere di Gal., t. V, 35.
§ Opere di Gal., t. X, 393.

take place and imagining a certain particular way, I had dared to say that five or six months after that when came the time of the summer solstice that the two little lateral stars would have returned,—and this followed; and they were seen then for a long time. Then having again stopped observations on account of Saturn being in the Sun's rays, I turned again to look at it and saw it with two mitres in place of the round stars which reduced it to the figure of an olive. However the middle ball was quite easily seen distinct and particularly two obscure spots placed in the middle of the attachments of the mitres or if we choose to say of the ears. Such it was observed for many years and now you, reverend Father, write that the mitres are seen transformed into two little round globes and so also other of my friends refer them to me; and it may be that in the three years in which I have not been able to see it,* it may have been another time restored solitary, and then may have returned to its first state in which I observed it at the beginning. It will concern others† in the future to make the observations, recording the time of the changes that their periods may be found with certainty, and when there are people who may have curiosity to do that which I have done for so long a time through not knowing how to do better."‡.

THE GRAPHIC CONSTRUCTION OF ECLIPSES AND OCCULTATIONS.

IV.—Occultations of Clusters.

WM. F. RIGGE, S. J.

For Popular Astronomy.

The occultation of a cluster of stars like that of the Pleiades or Præsepe possesses, of course, vastly more interest than that of a single star. And this interest is enhanced by the great rarity of the phenomenon, for although the Moon may pass through the cluster at each lunation for a whole year or more, we shall find in practice that the three conditions we have imposed upon the visibility of the occultation of a single star seem to be unduly severe in the case of a cluster. However, what chances are lost in one cluster may be gained in another, and the Ephemeris gives

* Galileo became totally blind in 1637 and died 8th January, 1642.

† Within 15 years after this, Huyghens, working as suggested by Galileo, discovered the true nature of the appendages.

‡ Opere di Gal., t. VII, 334.

us at least three every month during three years to come, 1896, 1897, 1898, the Pleiades in Taurus, Præsepe in Cancer, and a cluster in Scorpio. To these we may add several close stars in Aries, Gemini, Leo, Ophiuchus, Sagittarius, Capricornus and Pisces. These clusters or close stars may be discovered in the Ephemeris by glancing down the column marked "Washington Mean Time," where their number under a given date will at once arrest the eye.

In order to determine the elements of the occultation, that is, the times of the phases, position angles, and the like, for each star belonging to the cluster, we may make the construction we have explained in our last article for each individual star, and treat it therefore as if it were entirely alone in the sky. If we used this method, we should find that the ellipses on our drawings would remain practically the same, because the declinations of the stars, upon which the minor axes depend ($b = \cos \varphi \sin \delta$), do not differ to such an extent as to cause a perceptible change. The values of x' and y', the Moon's hourly motions in right ascension and declination, the slope of the Moon's path and the hourly motion thereon, would also be the same in all the diagrams, but the reading of the point G on the path and its distance from the centre of the disk would differ widely for the different stars. We might, it is true, draw all these parallel paths of the Moon on one diagram and use only one ellipse, but this method would at best be tedious and unsatisfactory and would give us nothing like what we expect to see in the sky; that is, it would not give us an exact representation on paper of the Moon's position and motion among the stars of the cluster as seen at a given place of observation, so that we might at any moment compare it with the reality and know what is to be the next phase of the phenomenon. Or, again, if we have a star chart or a map of the cluster, we may wish to plot the Moon's apparent path on it, and move the centre of a disk along this path, and thus obtain the order of time of the occultations, the times of the disappearances and reappearances, the position angles of the stars occulted on the Moon's disk, and all other interesting facts.

The construction of this apparent path of the Moon among the stars as it will appear to us when looking at the sky, is the object of the present article. The treatment of the subject evidently calls for some change in our usual method, because hitherto in the construction of our diagrams the Sun or star has been our point of view and from it we have observed the eclipse

of St. Louis, whilst now we must remain on Earth and plot the diagram on the sky. The transition however from the first point of view to the second will be made without difficulty, in fact we have unconsciously made it already in the two preceding articles, so that the main point of the present article will be to show how the information which a single star of the group will furnish us according to the usual method can be applied to the whole cluster. We shall then, after constructing what is called a relative path of the Moon, be occupied principally in laying down the stars themselves on our diagram in their relative configuration, that is, constructing the star chart itself, in case we do not possess a map of the cluster and are obliged to confine ourselves to the data given by the Ephemeris. And lastly, as the possession of such a map considerably abridges the work, at the same time that it furnishes us with more stars than are marked in the Ephemeris, we shall also indicate what changes are to be made in our diagram to adapt it to the map.

Selection of a Cluster. We select the occultation of the Pleiades on October 23, 1896, at St. Louis, as a practical example with which to illustrate the process. The data are to be found in the Ephemeris page 444. They are too numerous to copy entire, but we shall give all that are necessary as we proceed. We shall notice at once that 18 stars are noted down to be occulted on October 23. The times of conjunction of 14 of these do not differ much from one another, the greatest difference being less than half an hour. Outside this group there is a sudden interval of two hours on one side and nearly ten on the other. We shall confine our attention therefore to the stars between *g* Pleiadum and B. A. C. (British Association Catalogue) 1192. But first let us apply the tests of visibility. *First*, the hour must be convenient. The middle of the Washington mean times of conjunction is in the neighborhood of 11 P. M., that is, about 10 P. M. at St. Louis, which is $0^h\ 53^m$ west of Washington. The hour, therefore, is not too late. *Second*, the limiting parallels must include the latitude, $+ 38° 38'$. We see that all the stars except 23, 27 and 28 Tauri and B. A. C. 1192 stand this test. Four therefore drop out, and of the remaining ten 24 and η Tauri are so near the verge that there is little hope of their remaining. So that we must be satisfied with eight and perhaps sacrifice even some of these. *Third*, $H - \lambda$ must be less by one hour than the semidiurnal arc of the star. The value of H, the Washington hour angle of the middle of the group is about $- 2$ hours, that is, about 2 hours east of the meridian, and consequently nearly 3

hours east for St. Louis. As the semi-diurnal arc for + 24°, the declination of the centre of the group, is over 7 hours (about half an hour more than 6 hours for every ten degrees of north declination), we have the centre of the Pleiades about 4 hours above the horizon during the middle of the occultations. We have good reason therefore to expect favorable results from about eight of the stars.

Application of the Usual Method to the Central Star. As we have already intimated, we intend to derive the apparent path of the Moon among a cluster of stars from a diagram constructed for a single star according to the method of our last article. From this diagram we construct an apparent or relative path of the Moon with reference to that star, and then knowing the Moon's distance, bearing and motion with regard to one star, all we need do is, either to supply the other stars in our diagram, or to transfer it to a map of the cluster, and then to move a circle representing the Moon along this path and gather in a harvest of occultations with as much facility as we would investigate only one. The star that we select for this purpose ought to be somewhat near the centre of the cluster, so that errors in the construction may have less effect. We shall take 24 Tauri as our central star, its Washington mean time of conjunction being nearly half way between those of the first and last stars of the group. We might have taken η Tauri or Alcyone equally well. In fact, the nearness of Alcyone to 24 Tauriwas not noticed until the stars were plotted in position. But we shall adhere to 24 Tauri as our central star in order to show that any star, irrespective of magnitude, may be chosen for that purpose.

The large semi-circle in Fig. I represents as usual the northern half of the Earth's disk. The quarter ellipse is the path of St. Louis across the Earth's disk as seen from 24 Tauri during the time that concerns us. The declination of this star (Ephem. p. 444) is $\delta = + 23^\circ\ 48'$; the semi-major axis of the ellipse is $a = \cos \varphi = 0.782$; the semi-minor axis $b = \cos \varphi \sin \delta = 0.316$; the distance of its centre from the centre of the Earth's disk is $d = \sin \varphi \cos \delta = 0.568$. $OC = x' = 0.538$, and $CP = y' = +0.120$, determine the inclination of the Moon's path and the length OP of the hourly motion. $CG = Y = + 1.050$ = distance of the point G from C. H is $-2^h\ 4^m$, $\lambda = +0^h\ 53^m$ and $H - \lambda = -2^h\ 57^m$ = the local hour angle at conjunction and reading of the point G on the Moon's path, or the Moon's true path as it is called on the diagram. The local mean time of transit is $13^h\ 29^m$, the Washington time of conjunction *minus* the hour angle H.

All this is as usual, and we might investigate the occultation of the star, 24 Tauri, for which the diagram was drawn, in the usual manner, if we did not have another object in view. As a matter of fact, however, (and this may be instructive) this star is not occulted at all, because no two points showing the same time, one on the Moon's orbit and the other on the ellipse, can be found at a distance of 0.272, the Moon's semi-diameter. Still, this need not disconcert us, because we intend to use this diagram merely as a stepping stone to something better.

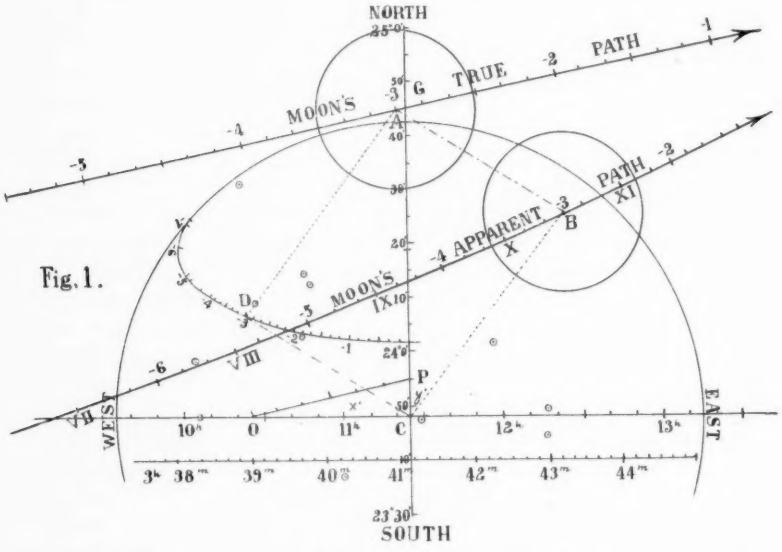


Fig. 1.

The Moon's Apparent Path. Seen from our distant station on the star 24 Tauri, St. Louis appears to move in that elliptical path one half of which is represented on the diagram, while the Moon moves along the straight line which is called the Moon's true path. The bearing and distance of the Moon from St. Louis are constantly changing. From being due west at about $-6^h\ 30^m$ it is due north at about $-4^h\ 15^m$, and then becomes northeast. If, now, the Earth's disk as seen from the star is so dark that the outlines of its continents are no longer distinguishable, and if St. Louis is the only visible point on the surface, then we have no fixed points to which we can refer the motion of St. Louis, and one of the two, St. Louis or the Moon, will seem to be fixed in space and the other to move in such a relative orbit

that the bearings and distances are in no wise changed, but the moving body will have a motion, which is compounded from the original motions of both bodies. If we imagine St. Louis to be the fixed point and the Moon to move, its orbit will then be only a relative or an apparent orbit, just as in the case of double stars where both bodies are really in motion about the common centre of gravity, but either one (conventionally the brighter one) is imagined to be fixed and the other to move about it with the sum of the motions of both. We shall imagine St. Louis to be placed immovably on the point C (in Fig. I), the center of the Earth's disk, and construct the Moon's apparent orbit relative to that point. From C we draw a line to B, equal and parallel to DA, D being the position of St. Louis at -3^h and A the Moon's position at the same time. Denoting B by -3^h, it is evident that the bearing and distance of B from C is the same as that of A from D, so that as far as appearances are concerned, we cannot say whether C and B or D and A are the positions of St. Louis and the Moon at -3^h as seen from the star, because their relative position is all that we can make out, and that is evidently the same in both cases. If we construct other points in a similar way and connect them by a curve, this curve will be the Moon's apparent path. This path is that large curve on our diagram which starts from the western end of the Earth's disk and runs obliquely upward towards the right, approaching continually (as far as the diagram extends) to the Moon's true path.

This curve which represents the Moon's apparent path is drawn practically in this way. We know from geometry that if two sides of a quadrilateral are equal and parallel, the other sides must also be equal and parallel. Hence at A or -3^h on the Moon's true path we draw the line AB equal and parallel to the one which joins D at -3^h on the ellipse with C the centreof the disk, and call the point B, -3^h. It is not necessary to draw real pencil lines on the paper, the dividers will measure the distance DC and the parallel rulers (or the triangle and ruler) will give us the direction AB parallel to DC, then applying one leg of the dividers at A we mark the impression made by the other with a little circle in pencil in order that we may find it again with ease. Then we shift the point -4^h on the Moon's true path to -4^h on the apparent path in a similar way. Other hourly and half-hourly positions are then shifted, a smooth curve, which may be said to be a succession of short straight lines, is drawn through these points, the ten minute marks are supplied by estimation, and the Moon's apparent orbit is finished. The hourly distances

will be seen to be unequal so that some care must be taken in the construction.

Change of Point of View. We shall now imagine the upper straight line (the Moon's true path), the ellipse and the Earth's disk erased from the drawing and use only the path we have just constructed. Looking down then from the star 24 Tauri, we see St. Louis fixed at C and the Moon moving along the curve which we have called its apparent path. The actual distance which separates the Moon from the Earth is of no consequence, because appearances would still be the same no matter how far away we may shift the point C, provided only it remains on the same straight line, that is, the line which joins the centre of the Earth and the star. The star's actual distance from the Moon and the Earth is for the same reason of no moment, provided only that it be large, that is, practically infinite. Hence, as our actual distance from the Moon does not change our view of its apparent orbit relative to St. Louis at the point C, so long as we remain on the Earth-star line, we may leave our familiar point of view on the star, travel down on the Earth-star line, pass the Moon on our way, and keep on our journey on the same line until we reach the point C itself, that is, St. Louis, or beyond, and then turning our eyes back see the star fixed and the Moon moving past it in the very same apparent orbit just as we saw it before move past St. Louis, with only this one difference, that as we are now practically looking on the other side of our drawing (because we have turned round to look back upon our journey) east and west have changed sides. The relative length of lines on our drawing is not affected by the change of the point of view, because if from the star the Moon's centre, is seen to be one and a half times its radius due north of St. Louis at $-4^h\ 15^m$, then from St. Louis the Moon will be seen at the same moment that same proportionate distance due north of the star.

Plotting the Cluster. From what has been said we may gather that all we have to do to transfer our diagram to the sky, is to reverse its right and left ends. This is done very expeditiously by turning the paper round and holding it against a light. We shall then see the star 24 Tauri fixed at the point C and the Moon moving along its apparent orbit exactly as it will appear to do on October 23. We have therefore but to complete the diagram by adding the other stars of the cluster. To do this we must know the scale.

This scale is derived from the size of the Moon on our drawing expressed in angular measure. As the angular value of the

Moon's semi-diameter is variable on account of the Moon's change of distance from the Earth, we must determine it especially for the middle of this occultation of the Pleiades. This will occur at about 9 P. M. For, we see from the diagram that $-4\frac{1}{4}$ hours is the Moon's local hour angle when crossing the axis of Y on its apparent path, that is, when in apparent conjunction with the central star of the group, 24 Tauri, which is at the point C. As the zero point, 0^h, on the Moon's orbit corresponds to $13^h\ 29^m$, the local mean time of the star's transit, as we saw before, this indicates that at about 9^h St. Louis time or 15^h Greenwich time the Moon will appear to be in the midst of the Pleiades. It is for this time that we must compute the Moon's semi-diameter.

On page 167 of the Ephemeris we see that at Greenwich midnight on Oct. 23 the Moon's semi-diameter is $14'\ 49''.2$. As it is increasing $2''.2$ in 12 hours, it will be $0''.5$ more at 15^h. Subtracting $2''.5$ (Ephem. p. 524) from this value, in order to take away the irradiation constant which has no existence in eclipses and occultations (and this is the reason why the Ephemeris calls the eclipse semi-diameter the *true* semi-diameter), we have $14'\ 47''.2 = 14'.79$ as the Moon's semi-diameter. As this is 0.272 on our scale, we find by proportion that $60' = 1^\circ = 1.105$. This, then, is the scale of our map or diagram when transferred to the sky, and we shall need it to lay down the stars in their relative positions. But as it is expressed in an arc of a great circle, it can be used to plot the stars only in declination. It will accordingly be found on Fig. I on the axis of Y, extending from $23^\circ\ 30'$ to $25^\circ\ 0'$ in such a way as to indicate $23^\circ\ 48'$ (the declination of 24 Tauri) for the point C.

In right ascension we may make use of the Moon's own motion in locating our stars. As the Ephemeris (p. 444) gives the time of the Moon's conjunction with each star, we can use its hourly motion in right ascension as the scale for the coördinate parallel to the east and west line, instead of using the right ascension of the star itself. We, therefore, construct a scale with $x' = OC = 0.538 =$ the Moon's motion in an hour as our unit. This scale is then to be applied to the axis of X (see Fig. I) in such a way that $11^h\ 25^m$, the Washington mean time of conjunction of the Moon with 24 Tauri, will fall on the point C. That these times are Washington times and not St. Louis times is of no consequence, because all we need is their differences.

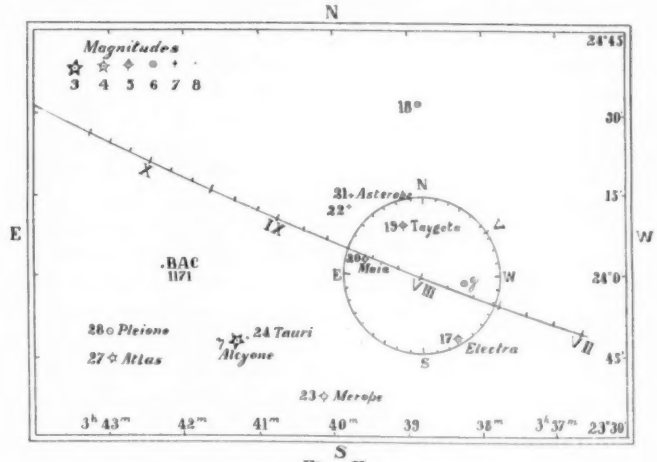
With the help of these two scales and the data given in the columns "Apparent Declination" and "Washington Mean

Time," it will not be difficult to locate all the stars given by the Ephemeris. This may be done very conveniently on Fig. I itself, for the reason that it contains the central star of the group at the point C and the Moon's apparent orbit. The necessary reversal of the east and west ends may be effected very quickly by the method to be mentioned in a few moments. Having copied the declination scale on the edge of a narrow strip of paper and drawn on it a line perpendicular to the edge at the point C (that is, at 23° 48′), we place this line on the axis of X and move the strip along until the graduated edge cuts the Washington time of conjunction of any star on the axis of X; then having found the declination of the same star on our declination scale, we mark the star's position on the diagram with a fine needle, and draw a little circle in lead pencil about the puncture in order to render it more visible. Names or letters or numbers may be added in pencil and afterwards erased.

The scale given at the bottom of Fig. I parallel to the axis of X and extending from $3^h\ 38^m$ to $3^h\ 45^m$ is a true right ascension scale. It was obtained from the declination scale by multiplying the length of 1° (1.105) by the cosine of 24° (the declination of the centre of the group) and dividing it by 4 (because $1° = 4^m$). The result, 0.252, is the length of 1^m of right ascension. This scale may serve for the insertion of stars not given in the Ephemeris, provided their right ascensions are known. But as we shall confine ourselves entirely to the Ephemeris, we shall not make use of it, and have given it merely for the sake of information and possible utility.

Now, turning Fig. I over and holding the paper against a window pane or a light, we copy all the stars we have just located, and also the Moon's apparent path on the other side of the same paper. By means of this simple contrivance of turning the paper over, we not only change the east and west ends, but also avoid the necessity of constructing a new diagram, or at least we gain in clearness by doing away with our construction lines. Fig. II is this reversed copy of the stars and the Moon's apparent orbit. The stars in Fig. II have been represented according to their magnitudes, and appropriately lettered or named. The stellar hour-angles on the Moon's path have, for the sake of greater convenience, been expressed in mean time. We know that 0^h on the Moon's path corresponds to $13^h\ 29^m$ local mean time, or $-4^h\ 0^m$ to $9^h\ 29^m$. Adding 1^m to this and thereby changing St. Louis local time to Central time, we replace $-4^h\ 0^m$ by $9^h\ 30^m$ or $-4^h\ 30^m$ by IX. This allows of our copying the 10^m marks unchanged.

Occultations of Individual Stars. We may now use our dividers or compass opened to the Moon's semi-diameter 0.272, and find the times of the immersion and emersion of individual stars, or we may take a piece of gelatine or mica or transparent paper with a circle of 0.272 radius on it, and move that along with its centre on the Moon's path. If this circle has its circumference graduated to 10° spaces and is correctly oriented, the position angles of the points of disappearance and reappearance of the stars with reference to the north point, may be obtained by mere inspection. The parallactic angles may be measured for every



Fig, II.

hour and supposed to vary uniformly. They are obtained very conveniently from Fig. I by placing the Moon at VIII or $-5^h\,30^m$ on its apparent orbit, orienting it correctly, and then drawing a line (by simply holding the ruler) from its center to $-5^h\,30^m$ on the Moon's true path. This will give the parallactic angle at sight. It will be found to be 52° at VII, 55° at VIII and 58° at IX P. M.

We shall find that six out of our eight stars are occulted, 18 Tauri and B.A.C. 1171 dropping out. The results are then as follows:

Star.	Mag.	Immersion.		Emersion.		Position Angle.	
						North Point	Vertex.
		h	m	h	m	°	°
Electra..... 17	4.3	7	16			S 74 E	159 E
g Pleiadum.....	6.3	7	16			N 64 E	117 E
Taygeta..... 19	5.0	7	47			N 40 E	94 E
Maia..... 20	5.0	7	54			N 73 E	128 E
Electra..... 17	4.3			8	3	S 32 W	93 W
22 Tauri.....	7.0	8	10			N 42 E	97 E
Asterope..... 21	7.0	8	11			N 32 E	87 E
g Pleiadum.....	6.3			8	14	S 75 W	49 W
Taygeta..... 19	5.0			8	41	N 81 W	24 W
Maia..... 20	5.0			8	57	S 64 W	58 W
Asterope..... 21	7.0			9	1	N 74 W	16 W
22 Tauri.....	7.0			9	7	N 85 W	27 W

Field Diagram. Fig. III is the usual field diagram, which will probably not require any explanation. The figures 7, 8, 9, are the vertices of the Moon at 7, 8, 9 o'clock. The apparent paths of the stars behind the Moon are neither straight lines nor are they parallel, because the Moon moves on a path of varying curvature and occults the stars at different times, but as these paths do not differ much from parallel straight lines, they furnish an obvious means of connecting the points of immersion and emersion of the same star.

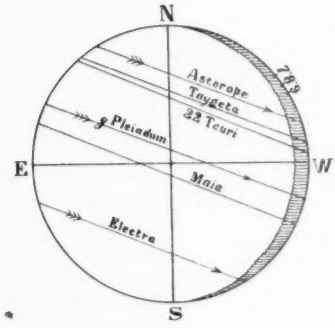


Fig. III.

The Moon's disk is unfortunately almost completely illuminated. Still, if the pleasure of seeing the immersions of the fainter stars at the bright limb must be foregone, there ought to be no difficulty in seeing the emersions of all of them at the dark limb, provided we keep only the most necessary part of the Moon's dark limb in the field of view of the telescope. In a clear sky there is no difficulty in seeing almost all the Ephemeris stars on Fig. II close to the full Moon. This was the case on November 3 of last year, when the Moon was but 1½ days past the full, and as the Moon on October 23, 1896, will be one day farther past the full phase, the chances of our seeing and enjoying the occultation of the Pleiades is increased in proportion. We should certainly prefer the Moon to be in the crescent phase, but that is as much beyond our control as the weather. More fortunate occultations of clusters than the present one can certainly be found in the Ephemeris with a little attention. We have selected this one be-

cause it is an occultation of the Pleiades, and because it occurs at an early hour of the night. If the reader is not averse to later hours or to early rising, he will find quite a number of good occultations of clusters throughout the year.

Application of the Method to a Star Map. A map of the cluster will considerably abridge our work, because it does away with the necessity of plotting the stars, besides adding quite a number which are not to be found in the Ephemeris and in catalogues. Clerke's System of the Stars contains an excellent map of the Pleiades, the scale of which is $1^\circ = 4.48$ inches. All that we must do in order to use this map is to adapt our scale to it. We have seen that 1° on our declination scale was equal to 1.105 on our plotting scale. Hence we have the proportion $1.105 : 1^\circ$ or 4.48-in. :: 1.000, the radius of the Earth's disk : 4.05 inches. Taking 4.05 inches therefore as our unit and radius of the Earth's disk instead of 3.33 inches (see second article in the January number, on page 249), we construct Fig. I in the usual way and lay down the Moon's apparent orbit. Reversing Fig. I, and copying the Moon's orbit on transparent paper which we lay upon the back of our diagram, we mark the point C and some other point such as G on the axis of Y. Then we place the transparent paper on the map in such a way that the point C falls on the central star (24 Tauri in the present case) and the line CG is parallel to a north and south line. Moving a transparent disk with the radius 0.272 along the Moon's path, we shall be able to predict the elements of the occultations of a large number of stars. Constructions of this kind will be especially valuable during a total eclipse.

GEORGETOWN COLLEGE OBSERVATORY,
Washington, D. C.

THE PLANETS AND THE CONSTELLATIONS FOR APRIL.

Mercury will be invisible behind the Sun during this month. He will be at superior conjunction April 17.

Venus is morning planet, seen toward the east an hour before sunrise. The phase of Venus increases from 0.90 to 0.95 while the brightness decreases from 66 to 56 during the month. On the mornings of April 10 and 11, the waning Moon will be near Venus, the conjunction of the two occurring April 10 at $9^h\ 57^m$ P. M., Central time.

Mars is visible, low in the southeast, at the same time with Venus. He is in Capricorn and will move northeastward through Aquarius in April. There are no first magnitude stars in this vicinity, so that the reader need have no difficulty in identifying the planet by his brightness and his ruddy color. The Moon will

pass Mars on the morning of April 8, at which time observers in the eastern part of the United States may see an occultation of the planet. The immersion will occur before the Moon rises at Washington but the emersion may be observed there at $3^h\ 56^m$ A. M. Washington time, or $4^h\ 4^m$ A. M., Eastern Standard time.

THE CONSTELLATIONS AT 9^h P. M., APRIL 1, 1896.

Jupiter will be at quadrature, 90° east from the Sun at noon April 19, and so will then cross the meridian at six o'clock P. M. On the next evening the Moon at first quarter will be near the planet, the two having been at conjunction at two o'clock in the afternoon. Very good views, perhaps the best, of Jupiter are obtained in strong twilight just after sunset. This month and next will be an excellent time to try such views. The great red spot will be near the meridian of Jupiter's disc at the following times in April :

Apr. 1	8 P. M.	Apr. 11	6 P. M.	Apr. 21	4 P. M.
2	4 "	12	12 midn.	22	10 "
3	9 "	13	8 P. M.	23	6 "
4	5 "	14	3 "	24	12 midn.
5	11 "	15	9 "	25	8 P. M.
6	7 "	16	5 "	26	3 "
7	3 "	17	11 "	27	9 "
8	8 "	18	7 "	28	5 "
9	4 "	19	3 "	29	11 "
10	10 "	20	8 "	30	7 "

Saturn rises in the southeast before 10 o'clock in the evening but does not reach a sufficient altitude for good observations until about midnight. We will wait therefore another month before publishing tables of the satellites. Saturn and the Moon will be in conjunction April 28 at 1^h A. M.

Uranus is about 5° southeast of Saturn in the constellation Libra. His right ascension April 1 is $15^h\ 27^m$ and declination south 18° 30′.

Neptune is in Taurus in right ascension $4^h\ 58^m$ and declination north 21° 17′.

Occultations Visible at Washington.

Date 1896.	Star's Name.	Magnitude.	IMMERSION. Washington M. T. h	m	Angle f'm N pt. °	EMERSION. Washington M. T. h	m	Angle f'm N pt. °	Duration. h	m
April 1	τ Scorpii	3.2	13	41	137	15	2	257	1	21
5	B.A.C. 7049	6.5	14	29	42	15	27	293	0	58
7	Mars†		14	48	56	15	56	260	1	8
15	19 Tauri	5.0	8	40	122	9	25	228	0	45
15	18 Tauri	6 3	8	53	21	9	17	329	0	24
15	21 Tauri‡	7.0	8	56	102	9	37	248	0	41
15	22 Tauri‡	7.0	9	0	109	9	48	241	0	48
20	η Cancri	5.4	10	59	143	11	51	271	0	52
20	*39 Geminorum	6.3	14	4	57	14	32	345	0	28
20	*40 Geminorum	6.3	14	4	67	14	37	336	0	33
22	44 Leonis	6.0	13	17	118	14	12	302	0	55
23	75 Leonis	5.7	13	11	134	14	10	291	0	59
23	76 Leonis	6.3	14	13	154	14	59	265	0	46
28	4 Scorpii†	6.3	8	12	172	8	40	232	0	28
30	B.A.C. 6127	5.1	10	8	83	11	9	291	1	1

* Whole occultation below the horizon of Washington; † Immersion below the horizon of Washington; ‡ Emersion below the horizon of Washington.

E. E, Barnard's Measures of the Saturnian System.—From the January *Monthly Notices*, we take the following as the results of Mr. Barnard's work for two years on the Saturnian system. The numbers are in English miles, the Sun's mean distance being 92,879,000 miles.

Equatorial diameter of Saturn	76,470 miles
Polar diameter of Saturn	69,770 "
Outer diameter of outer ring	172,310 "
Inner diameter of outer ring	150,566 "
Outer diameter of inner ring	146,020 "
Inner diameter of inner ring	110,200 "
Inner diameter of Crape ring	88,190 "
Width of Cassini Division	2,270 "
Diameter of Titan	2,720 "

These values differ considerably from others usually accepted at good authority.

Jupiter's Satellites for April.

Central Standard Time.

Phases of the Eclipses of the Satellites for an Inverting Telescope.

I. r

III. d r

II. r

IV. d r

Configuration 9h 0m p. m. for an Inverting Telescope.

Day.	West.	East.
1	·3 2· 1·	○ 4·
2	·2	○ ·3 ·1 4·
3	1·	○ ·2 4· ·3
4	○4·	○ 2· 1· 3·
5	4· 2· ·1	○ 3·
6	4· 3·	○ 1· ·2●
7	4· 3·	○ 2· ·1●
8	4· ·3 2· 1·	○
9	·4 ·2	○ ·1 ·3●
10	·4 1·	○ ·2 ·3
11	·4	○ 2· ·1 3·
12	2· ·1 ·4	○ 3·
13	3·	○ 1· ·4 ·2●
14	3· ·1	○ 2· ·4
15	○1· ·3 2·	○ ·4
16	·2 ·3	○ ·1 ·4
17	1·	○ ·2 ·3 4·
18		○ ·1 2· ·3 4·
19	2· ·1	○ 3· 4·
20	·2 3·	○ 1·4·
21	3· ·1 4·	○ ·2
22	○2· ·3 4·	○ 1·
23	4· ·2 ·3	○ ·1●
24	4· 1·	○ ·2 ·3
25	·4	○ ·1 2· ·3
26	·4 2· 1·	○ ·3
27	○3· ·4 ·2	○ ·1
28	3· ·4 ·1	○ ·2
29	○2· ·3	○ 1· ·4●
30	·2 ·3	·1○ ·4

Phenomena of Jupiter's Satellites.

Central Time.

	h	m			
Apr. 1	12	39	P. M.	II	Sh. In.
	1	10	"	II	Tr. Eg.
	3	35	"	II	Sh. Eg.
	4	31	"	I	Tr. In.
	5	44	"	I	Sh. In.
	6	51	"	I*	Tr. Eg.
	9	4	"	I*	Sh. Eg.
2	1	41	"	I	Oc. Dis.
	5	5	"	III	Oc Dis.
	5	13	"	I	Ec. Re.
	8	43	"	III	*Oc. Re.
	10	8	"	III	*Ec. Dis.
3	1	41	A. M.	III	Ec. Re.
	5	11	"	II	Oc. Dis.
	10	30	"	II	Ec. Re.
	10	59	"	I	Tr. In.
	12	13	P. M.	I	Sh. In.
	1	19	"	I	Tr. Eg.
	2	33	"	I	Sh. Eg.
4	8	9	A. M.	I	Oc. Dis.
	11	42	"	I	Ec. Re.
	4	16	P. M.	IV	Tr. In.
	8	55	"	IV*	Tr. Eg.
	11	32	"	II*	Tr In.
5	1	58	A. M.	II*	Sh. In.
	2	27	"	II	Tr. Eg.
	4	2	"	IV	Sh. In
	4	54	"	II	Sh. Eg.
	5	27	"	I	Tr. In.
	6	42	"	I	Sh. In.
	7	47	"	I	Tr. Eg.
	8	50	"	IV	Sh. Eg.
	9	2	"	I	Sh. Eg.
6	2	37	"	I	Oc. Dis.
	6	11	"	I	Ec. Re.
	7	7	"	III	Tr. In.
	10	45	"	III	Tr. Eg.
	11	10	"	III	Sh. In.
	3	52	P. M.	III	Sh. Eg.
	11	48	"	II*	Oc. Dis.
	11	55	"	II*	Ec. Re.
7	1	11	A. M.	I*	Tr. In.
	2	15	"	I*	Sh. In.
	3	31	"	I	Tr. Eg.
	9	6	P. M.	I	Sh. Eg.
8	12	40	A. M.	I*	Oc. Dis.
	12	49	P. M.	I*	Ec. Re.
	3	17	"	II	Tr. In.
	3	44	"	II	Sh. In.
	6	13	"	II	Tr. Eg.
	6	23	"	II*	Sh. Eg.
	7	39	"	I*	Tr. In.
	8	43	"	I*	Sh. In.
	9	59	"	I*	Tr. Eg.
9	3	34	"	I*	Sh. Eg.
	7	8	"	I	Oc. Dis.
	8	57	"	I*	Ec. Re.
10	12	35	A. M.	III*	Oc. Dis.
	2	9	"	III*	Oc. Re.
	5	41	"	III	Ec. Dis.
10	7	42	A. M.	III	Ec. Re.
	12	51	P. M.	II	Oc. Dis.
	1	5	"	I	Tr. In.
	2	8	"	II	Ec. Re.
	3	11	"	I	Sh. In.
	4	28	"	I	Tr. Eg.
11	10	3	A. M.	I	Sh. Eg.
	1	37	P. M.	I	Oc. Dis.
12	2	6	A. .M	I	Ec. Re.
	4	36	"	II	Tr. In.
	5	0	"	II	Sh. In.
	7	20	"	II	Tr. Eg.
	7	32	"	I	Tr. In.
	8	37	"	II	Sh. Eg.
	9	40	"	I	Sh. In.
	10	57	"	I	Tr. Eg.
13	2	42	"	I	Sh. Eg.
	4	31	"	IV	Oc. Dis.
	6	21	"	I	Oc. Dis.
	8	6	"	IV	Oc. Re.
	11	1	"	I	Ec. Re.
	1	56	P. M.	III	Tr. In.
	2	39	"	IV	Ec. Dis.
	4	9	"	III	Tr. Eg.
	6	38	"	III	Sh. In.
	7	51	"	IV*	Ec. Re.
	8	59	"	III*	Sh. Eg.
14	1	48	A. M.	II*	Oc. Dis.
	2	23	"	I	Tr. In.
	3	5	"	II	Ec. Re.
	4	8	"	I	Sh. In.
	5	25	"	I	Tr. Eg.
	11	0	P. M.	I	Sh. Eg.
15	2	35	A. M.	I	Oc. Dis.
	3	24	P. M.	I	Ec. Re.
	5	54	"	II	Tr. In.
	6	19	"	II	Sh. In
	8	17	"	II*	Tr. Eg.
	8	50	"	I*	Tr. In.
	9	34	"	II*	Sh. Eg.
	10	37	"	I*	Sh. In.
	11	54	"	I*	Tr. Eg.
16	5	29	"	I*	Sh. Eg.
	9	4	"	I*	Oc. Dis.
17	12	54	A. M.	I*	Ec. Re.
	4	32	"	III	Oc. Dis.
	6	9	"	III	Oc. Re.
	9	42	"	III	Ec. Dis.
	10	16	"	III	Ec. Re.
	2	46	P. M.	II	Oc. Dis.
	3	40	"	I	Tr. In.
	4	3	"	II	Ec Re.
	5	6	"	I	Sh. In.
	6	23	"	I	Tr. Eg.
18	11	57	A. M.	I*	Sh. Eg.
	3	33	P. M.	I	Oc. Dis.
19	4	43	A. M.	I	Ec. Re.
	7	13	"	II	Tr. In.
	7	38	"	II	Sh. In.
	9	14	"	II	Tr. Eg.

19	10	9	A. M.	I	Tr. In.
	10	31	"	II	Sh. Eg.
	11	34	"	I	Sh. In.
	12	51	P. M.	I	Tr. Eg.
20	6	27	A. M.	I	Sh. Eg.
	10	2	"	I	Oc. Dis.
	2	58	P. M.	I	Ec. Re.
	6	37	"	III	Tr. In.
	8	9	"	III*	Tr. Eg.
	11	33	"	III*	Sh. In.
	11	51	"	II*	Oc. Dis.
21	3	43	A. M.	III*	Sh. Eg.
	4	58	"	I	Tr. In.
	5	0	"	II	Ec. Re.
	6	3	"	I	Sh. In.
	7	20	"	I	Tr. Eg.
	9	55	"	I	Sh. Eg.
	2	35	P. M.	IV	Tr. In.
	10	3	"	IV	Tr. Eg.
22	12	55	A. M.	IV*	Sh. In.
	2	53	"	I	Oc. Dis.
	4	30	"	IV	Sh. Eg.
	6	2	P. M.	I	Ec. Re.
	8	32	"	II	Tr. In.
	8	57	"	II*	Sh. In.
	10	12	"	II*	Tr. Eg.
	11	28	"	I*	Tr. In.
	11	29	"	II*	Sh. Eg.
23	12	32	A. M.	I*	Sh. In.
	1	49	"	I	Tr. Eg.
	7	24	P. M.	I	Sh. Eg.
	10	59	"	I*	Oc. Dis.
24	4	54	A. M.	I*	Ec. Re.
	8	33	"	III	Oc. Dis.
	10	9	"	III	Oc. Re.
	12	51	P. M.	III	Ec. Dis.
	1	42	"	II	Oc. Dis.
	4	41	"	III	Ec. Re.
	5	57	"	I	Tr. In.
	6	15	"	I	Sh. In.
	7	1	"	II	Ec. Re.
24	8	17	P. M.	I*	Tr. Eg.
25	1	53	"	I*	Sh. Eg.
	5	28	"	I	Oc. Dis.
26	7	21	A. M.	I	Ec. Re.
	9	51	"	II	Tr. In.
	10	16	"	II	Sh. In.
	11	10	"	II	Tr. Eg.
	12	26	P. M.	I	Tr. In.
	12	48	"	I	Sh. In.
	1	30	"	II	Sh. Eg.
	4	46	"	I	Tr. Eg.
27	8	22	A. M.	I	Sh. Eg.
	11	57	"	I	Oc. Dis.
	7	0	P. M.	I	Ec. Re.
	10	38	"	III*	Tr. In.
28	12	8	A. M.	III*	Tr. Eg.
	2	9	"	III	Sh. In.
	3	50	"	II	Oc. Dis.
	5	39	"	III	Sh. Eg.
	6	55	"	I	Tr. In.
	7	32	"	I	Sh. In.
	7	59	"	II	Ec. Re.
	9	15	"	I	Tr. Eg.
29	2	51	A. M.	I	Sh. Eg.
	6	26	"	I	Oc. Dis.
	7	49	P. M.	I	Ec. Re.
	8	40	"	IV*	Oc. Dis.
	11	10	"	II*	Tr. In.
	11	35	"	II*	Sh. In.
30	12	8	A. M.	II	Tr. Eg.
	12	30	"	I	Tr. In.
	1	23	"	IV	Oc. Re.
	2	6	"	I	Sh. In.
	2	28	"	II	Sh. Eg.
	3	43	"	I	Tr. Eg.
	7	59	"	I	Sh. Eg.
31	12	43	P. M.	IV	Ec. Dis.
	9	21	"	IV	Ec. Re.
	12	55	A. M.	I*	Oc. Dis.
	8	58	"	I	Ec. Re.

Minima of the Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time.]

U CEPHEI.

1896.

	d	h
May	3	18
	8	17
	13	17
	18	17
	23	16
	28	16

S CANCRI.

May	1	13

δ LIBRÆ.

May	2	14
	4	22

δ LIBRÆ Cont.

1896.

	d	h
May	9	14
	11	22
	16	13
	18	21
	23	13
	25	21
	30	13

U CORONÆ.

May	5	19
	12	17
	19	14
	29	23

U OPHIUCHI.

1896.

	d	h
May	4	22
	5	18
	6	14
	9	22
	10	18
	11	15
	14	23
	15	19
	16	15
	19	24
	20	20
	21	16
	22	12

U OPHIUCHI.

1896.

	d	h
May	25	21
	26	17
	27	13
	30	22

D. M. + 17°,4367.

May	4	18
	9	13
	14	8
	19	4
	23	23
	28	18

Note the change from Central Standard Time to Greenwich Mean Time, which is now universally used for variable star ephemerides.

The data for the Algol stars are taken as usual from Hartwig's ephemeris, except the dates for D. M + 17°, 4367, which were computed with same period as last month. Professor Pickering has published in the March Astrophysical Journal an ephemeris of this star for the remainder of the year. The above times agree with his, except that he gives May 28, $18^h\ 31^m$. Professor Pickering has used the same period which I used, $4^d\ 19^h\ 21^m.2$ ($4^d.8064$) but has used a slightly different zero epoch, hence the above difference. J. A. PARKHURST.

Marengo, Ill., 1896, March 6.

Maxima and Minima of Long Period Variables.

MAXIMA.

1896 May

Date	No.	Star.
1	5950	W Herculis
2	2080	R Columbæ
4	7659	T Capricorni
6	5237	R Bootis
8	5070	Z Virginis
12	7139	RR Sagittarii
13	4492	Y Virginis
16	5675	V Coronæ
16	103	T Andromedæ
18	8324	V Cassiopeæ
20	7468	T Aquarii
20	976	T Arietis
22	7242	S Aquilæ
23	2528	R Geminorum
24	112	R Andromedæ
24	7733	Y Capricorni
26	5501	S Serpentis
27	7220	S Cygni
27	5405	RT Libræ
28	7450	V Aquarii
28	7252	W Capricorni
28	6921	S Sagittarii
29	1717	V Tauri
30	4847	S Virginis
30	4816	V Virginis

MAXIMA CONT.

1896 May.

Date	No.	Star.
31	1771	R Leporis

1896 June.

2	5830	R Scorpii
3	6044	S Herculis
3	6512	T Herculis
3	7944	T Pegasi
4	1574	W Tauri
5	845	R Ceti
5	2742	S Geminorum
6	4896	T Centauri
6	4557	S Ursæ Maj.
7	7571	V Capricorni
9	5831	S Scorpii
10	7431	S Delphini
11	7118	X Aquilæ
12	7444	T Delphini
13	5593	W Libræ
16	5583	X Libræ
16	5776	X Scorpii
21	5617	U Libræ
23	2778	W Puppis
26	5795	W Scorpii
26	906	R Trianguli
26	7560	R Vulpeculæ

MINIMA.

1896 May.

Date	No.	Star.
4	3186	T Cancri
4	466	U Piscium
10	5677	R Serpentis
24	5338	U Bootis
26	2684	S Canis Min.
26	8591	V Cephei
27	2625	V Geminorum
28	4521	R Virginis
31	2976	V Cancri
31	4511	T Ursæ Maj.

1896 June.

1	1981	S Camelopardalis.
2	5758	X Herculis
3	7456	RR Cygni
4	6943	T Sagittæ
10	243	U Cassiopeæ
11	62	S Sculptoris
12	980	V Persei
12	494	R Sculptoris
15	5955	R Draconis
24	2735	U Canis Min.

NOTE:—980 V Persei of Chandlers's catalogue is called W Persei in Hartwig's ephemeris.

The Variable Star 5190 R Camelopardalis.—Mr. W. Dearden, of Trinidad, Colo., has sent me 13 observations of this variable, beginning 1895, Sept. 20, and ending 1896, Feb 14. A graphic reduction shows a minimum about the 13th magnitude, 1895, Dec. 27. This gives a correction to the elements in Chandler's Second Catalogue, of 49 days. That catalogue tells us that the variability of this star was discovered by Hencke in 1858. The period there given is 269.5 days, and the remarks are added "Periodic inequality," and "Light curve somewhat irregular." The zero epoch is taken as 1869, Aug. 29, and the minimum is said to precede the maximum by 135 days. These elements are based upon observations of 31 maxima and 7 minima between 1862 and 1892. In the Annals of the Harvard College Observatory, Vol. XVIII, there are indexed 301 observations made in the years 1883 to 1887, inclusive. This shows that the

star has not been neglected, the reasons being that it is near the pole and therefore visible through the year, also its range is considerable and its change at times rapid.

Since 1891 I find records of 4 maxima and 6 minima. The inequality of the variation is shown by the following table:

Phase	Epoch	Date		Correction to elements	Observer.
		Julian	Calendar		
Max.	29	2411768	1891 Feb. 4	+ 14 days,	Reed.
Max.	30	2028	1891 Oct. 22	+ 4	Yendell.
Max.	30	2032	1891 Oct. 26	+ 8	Dunèr and Reed.
Min.	31	2198	1892 Apr. 9	+ 40	Dunèr.
Max.	31	2298	1892 July 18	+ 4	Dunèr.
Max.	31	2297	1892 July 17	+ 3	Reed.
Min.	32	2446	1892 Dec. 13	+ 18	C. E. Peek.
Min.	33	2719	1893 Sep. 12	+ 22	J. A. Parkhurst.
Max.	33	2836	1894 Jan. 7	+ 4	Reed.
Max.	33	2842	1894 Jan. 13	+ 10	J. A. Parkhurst.
Min.	34	2995	1894 June 15	+ 38	W. Dearden
Min.	34	2994	1894 June 14	+ 37	J. A. Parkhurst.
Min.	35	3272	1895 Mar. 19	+ 36	W. Dearden.
Min.	35	3269	1895 Mar. 16	+ 33	J. A. Parkhurst.
Min.	36	2413555	1895 Dec. 27	+ 49	W. Dearden.

The persistence of the positive sign in the corrections would seem at first sight to indicate that the period is lengthening, but is more probably due to the fact that the "sine term" in the elements is positive during the seven periods involved.

The range of magnitude at maximum in the above list is from 7.2 to 8.4, at minimum from 11.4 to 13. J. A. PARKHURST.

COMET NOTES.

We have been unfortunate in several instances in not being able to give our readers the news of discovery of comets as promptly as we could wish, because the information came just after POPULAR ASTRONOMY had gone to press. In the last instance, owing to a misunderstanding as to the nature of the first observation of the new comet, the discovery was not regularly announced to astronomers at all and we had the embarassment of having to receive from newspaper reporters information which they came to get from us. This embarassment was all the greater since so much ado was made about the comet's motion being directly toward the Earth. Queries came from every quarter concerning the probability of a collision and what the consequences might be. The explanation of the misunderstanding is given in an interesting manner in the following note by Mr. John Ritchie, Jr., which we copy entire from the *Boston Commonwealth* of March 14. Mr. Ritchie is the Boston center for collecting and distributing astronomical information.

A COMET BY ACCIDENT.

The story of the discovery of the present comet is one of the most curious of the times, since the finding of it is owing to an accident pure and simple. It is quite true that it might not have got away without someone seeing it but at the same time this would not have been at all impossible.

The story as developed from correspondence shows that the object was first seen by Professor Perrine at Lick Observatory, but he at the time supposed that he was observing an object already discovered by astronomers at Kiel in Prussia.

According to the present methods of collecting and distributing astronomical information, two centres exist, Kiel and Boston. Discoveries made in this country are communicated to Boston and notice is thereupon sent to Kiel by cable. On the other hand, discoveries made in any other part of the world are sent to Kiel and thence distributed over Europe and sent to Boston, from which place the American distribution is effected. When the news is of such nature that the southern hemisphere should receive notice, this is sent from Kiel; and on the other hand discoveries made at southern Observatories, like the Cape of Good Hope or Australia, are sent at once to the European centre. Kiel and Boston represent therefore the centres, and frequent communication is maintained between these points by cable, by matters even of minor importance.

In will be remembered that in November last Professor Perrine of Lick Observatory discovered a telescopic comet. The orbits which were computed for it showed that its time of perihelion passage was in December, and since the comet passed at that time near the Sun's place in the sky, it disappeared. This disappearance is not necessarily a feature of the perihelion passage, which is the name for the nearest point of approach of the comet to the Sun, for this might lie in space outside of the Earth's orbit and the Earth might be very near it, and it might be at its brightest at the time. But when the place of perihelion passage in the sky lies near the position of the Sun, then the comet fades from view for a time or perhaps altogether. Some whole returns of comets have been so nearly in line with the Sun that at no time could they be seen, although from later returns, when they were seen, it has been evident that they must have been nearly in the computed place.

So, since its place in the sky lay near that of the Sun, Perrine's comet duly faded from view, and it was also evident that a while later it would again come into view. So one or two astronomers kept watch of the place where the comet might be expected to appear after perihelion passage, and on February 13 the object was seen at Kiel, and notice of this was sent to this country. The position of the comet was distributed here, as has been the custom, so that those astronomers who are interested in comets might know that the object was again in sight and could then proceed to observe it without being obliged to waste their time searching for it before it was really visible.

Among the other Observatories, Lick had notice of the sight of the comet at Kiel. But Perrine had naturally had much interest in his own comet, and he, before this—some weeks before, in fact—had found the comet and had been observing it from night to night. In some way the position of the object which was seen at Kiel, when it came to be used by the Lick astronomers, had been altered so that the position where the comet was supposed to be was quite a little different from its true position. This difference in position convinced Perrine that the object was not his comet of last year, which he had seen a number of times lately, and he therefore pointed his telescope to the place which his mistaken figures indicated. There, within the distance that it might be necessary to allow for the motion of a comet, he found the present one, Comet *a* 1896. But at the time and for a couple of weeks thereafter he supposed that it was the comet which had been seen at Kiel.

As was natural, he at once notified Boston that the Kiel comet was new, and this information was communicated to Kiel. Kiel knew very well, however, that the object which it had seen on February 13 was the comet of last year, and suspected at once that there was really a new comet in the vicinity and it was looked for. The new comet was therefore found at Kiel within a few hours of its discovery at Lick.

The circumstances are altogether very curious. The position at which Perrine pointed his telescope was a purely accidental one, and comparable indeed to the pointing of a telescope by accident. The chance of setting up a telescope at random and having an unexpected comet appear in it is about the same as of having a mistake in the position of one comet which would indicate the place of another, the two objects being in nowise related.

This calls to mind some curious facts with reference to comets and their discovery. Once at least an observer, in looking for one comet to observe it, has found another and a different comet. There is an instance, in the solar eclipse visible in Egypt in 1882, of a comet which was visible only during the few minutes of totality. This was a comet which lay close to the Sun, so close, in fact, as to be invisible, and which when the Sun was obscured became a prominent object in the sky, for it had quite a length of tail. This comet had not been seen before the eclipse and no other observation of it was secured.

Two years ago a similar comet was seen close up against the Sun on the photographic plates taken by the Lick Observatory expedition and some others of the parties sent to South America to observe the obscuration.

One or two curious facts have been noted in connection with the discovery of other comets. One of the most remarkable of these coincidences is related by Professor Boss, Director of Dudley Observatory. It was at the time several years ago when Swift, Brooks and Barnard were all actively searching for comets, and so energetic were these Americans that for quite a number of years no comet was discovered anywhere else, save in the far South in some position where it could not be seen at all by northern observers. Some of the people of Albany, who were beginning to take renewed interest in their Observatory—an interest which has resulted in a new building and an equipment comparable with those of the newer institutions—approached Professor Boss and in an informal way said that other institutions were discovering comets, and certainly Albany should not be behind the times. In a joking way Professor Boss spoke to his assistant and said to him—Wells was his name—"You see, Mr. Wells, you must discover a comet." And straightway Mr. Wells did as directed, and produced the desired comet within a week.

Perrine's Comet *c* 1895 and the Perrine-Lamp Comet *a* 1896.—The accompanying diagrams may help our readers to see how the new comet came to be discovered by accident. Fig. 1 shows the portion of the constellation Aquila in which the two comets were at the time of the discovery. Perrine's comet was at *A* on the morning of Feb. 15 while the new one happened to be at *B* just a little south of the former and about 5° west. A mistake of 20^m in the right ascension in setting the telescope for Perrine's comet would bring it so near the new comet that the latter must be visible in the field of the finder. The next morning at Kiel, about two-thirds of a day after Perrine's discovery the new comet was at *C* still nearly on a parallel with the old one so that it was easily found.

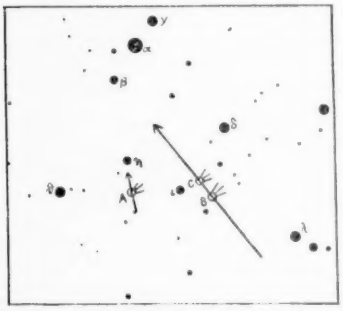


Fig. 1. Comets *c* 1895 and *a* 1896 in the Constellation Aquila.

The two comets appear in this cut to have been close together, but in reality

one was about four times as far from the Earth as the other. Fig. 2 shows the relative positions of their orbits with that of the Earth and Venus. On Feb.

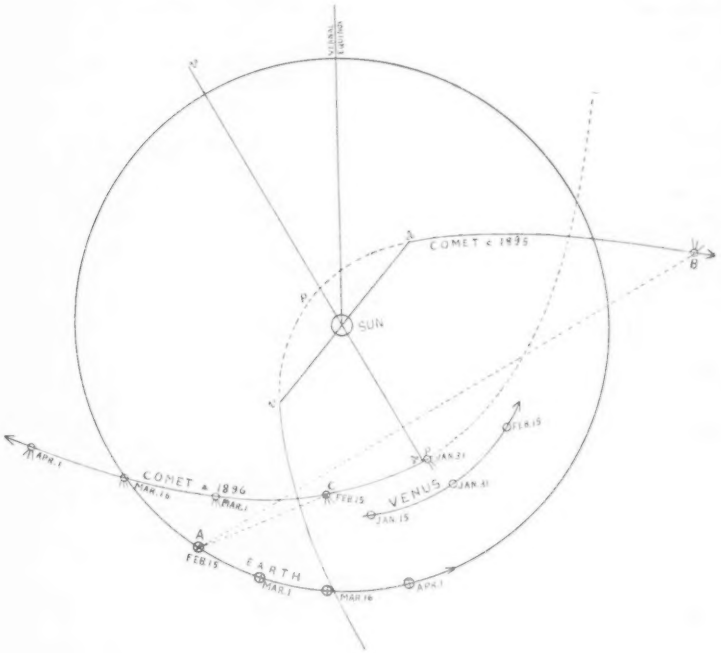


Fig. 2. The Orbits of Comet *a* 1896, and *c* 1895.

15 the Earth was at *A*, the old comet at *B*, and the new one at *C*. The one comet was moving away from the Earth, the other toward it. A glance at the diagram, however, shows that there was no probability that at any time the new comet would come at all near the Earth. If also we can imagine the orbit of the comet, as shown in the diagram, to be rotated about the line ♈ ♎ until the left half is inclined above the plane of the page at an angle of 24°, we shall get a truer idea of its relation to the Earth's orbit. The comet did not cross the Earth's path at all and did not approach within many million miles of it.

The new comet has moved rapidly north-eastward from Aquila, through Cygnus, Andromeda, Cassiopeia and Perseus. It was brightest when discovered and has rapidly decreased so that now its light is less than one-tenth. On March 19 it was an inconspicuous object although easily seen with a 5-inch telescope. Its decrease in April will be rapid, so that probably it will be seen only with the aid of large telescopes. The following ephemeris is the latest that we have:

Ephemeris of Comet *a* 1896 (Perrine-Lamp.)

[From *Astronomische Nachrichten*, No. 3338].

Berlin Midn.	R. A.			Decl.		log *r*	log Δ	Brightness
	h	m	s	°	′			
March 26	4	1	53	+ 43	43	0.1003	0.1291	0.04
27		4	26		43	29		
28		6	51		43	15	0.1111	0.1513	0.03
29		9	9		43	2		
30		11	22		42	49	0.1215	0.1722	0.03
31		13	30		42	37		
April 1		15	33		42	26	0.1318	0.1920	0.03
2		17	31		42	15		
3	4	19	25	+ 42	5	0.1417	0.2107	0.02

Elements of Comet *a* 1896.

Computer	Chandler	Lamp
T	1896 Jan. 31.76287 Gr. M. T.	1896 Jan. 31.79848 Ber. M. T.
ω	358° 22′ 28″.9	358° 19′ 48″.1
Ω	208 55 51 .7	208 53 13 .0
i	155 47 38 .1	155 46 32 .3
log *q*	9.768752	9.768740

Ephemeris of Comet *c* 1895.

[From *Astronomische Nachrichten* 3338]

Berlin Midn.	R. A.			Decl.		log *r*	log Δ	Brightness
	h	m	s	°	′			
April 1	19	36	0	+ 10	52.5	0.3569	0.3580	0.07
5		32	46		12	1.2		
9		29	3		13	9.5	0.3796	0.3551	0.07
13		24	50		14	17.2		
17		20	4		15	23.9	0.4007	0.3526	0.06
21		14	47		16	29.1		
25		8	58		17	32.2	0.4204	0.3511	0.06
29	19	2	39		18	32.6		
May 3	18	55	49	+ 19	29.7	0.4388	0.3515	0.05

Observations of Comet *a* 1896, by J. A. Parkhurst.—Perrine's comet *a*, 1896, was observed here as soon as Chandler's ephemeris in *Astronomical Journal*, No. 367, was received. Its place has been measured on five evenings with the filar micrometer attached to the 6-inch reflector, with the following results:

Central Standard Time.			Comet's Apparent Place. R. A.			Decl.			Correction to Ephemeris.	
	h	m	h	m	s	°	′	″	s	
March 2	7	19	0	47	56.5	+ 51	33	37	− 20	− 0.1
3	7	21	1	9	27.6		51	46	6	− 19	+ 0.5
4	7	18	1	28	40 8		51	44	11	− 20	+ 1.0
7	7	22	2	14	28.2		50	49	33	− 20	+ 1.6
8	7	28	2	26	26.1	+ 50	23	12	− 19	+ 1.9

NOTES.—March 2, seeing poor, no nucleus or tail; slight central condensation.
March 3, central condensation more evident.
March 4, seeing good. Condensation plainer than last night.
March 7, seeing fair, only one comparison in R. A. secured before clouds interfered.
March 8, decrease in brightness very slight. Comparison stars poorly placed and measures less reliable than usual.

In the above measures the places of the comparison stars were taken from the Cambridge Astronomische Gesellschaft Catalogue. J. A. PARKHURST.

Marengo, Ill., March 10, 1896.

PRACTICAL SUGGESTIONS

When does the New Moon begin? Young says, when in conjunction. The International Dictionary says the Moon is new when first appearing after conjunction. Which is right? W. E. K.

Answer. Young is right. The other view has some currency as a popular idea, but it is incorrect. When the astronomer says that the Moon, for example, is 18 hours old, he means that it is 18 hours past the time of conjunction.

Auxiliary Quantities for Computing Precession.—The following tables taken from *Astronomische Nachrichten*, No. 3318, will be found very useful in reducing star places from the various epochs of the star catalogues in common use to 1896 and 1897. The table was prepared by Dr. H. Kreutz, of Kiel, Germany.

Auxiliary Quantities for Computing Precession according to Struve for Several Common Epochs:

	$t = 1896.0$				$t = 1897.0$			
t_0	$m s(t-t_0)$		$\lg[m s(t-t_0)]$	$\lg[n''(t-t_0)]$	$t°$	$m s(t-t_0)$	$\lg[m s(t-t_0)]$	$\lg[n''(t-t_0)]$
	m	s				m	s		
1790	+ 5	25.594	2.151481	3.327572	1790	+ 5	28.667	2.155558	3.331649
1800	+ 4	54.886	2.108437	3.284528	1800	+ 4	57.959	2.112937	3.289028
1810	+ 4	24.177	2.060654	3.236745	1810	+ 4	27.250	2.065074	3.241765
1825	+ 3	38.110	1.977400	3.153491	1825	+ 3	41.183	1.983473	3.159564
1830	+ 3	22.753	1.945681	3.121772	1830	+ 3	25.826	1.952211	3.128302
1835	+ 3	7.396	1.911463	3.087554	1835	+ 3	10.468	1.918524	3.094615
1836	+ 3	4.324	1.904283	3.080374	1836	+ 3	7.396	1.911461	3.087552
1840	+ 2	52.038	1.874316	3.050407	1840	+ 2	55.111	1.882002	3.058093
1842	+ 2	45.895	1.858520	3.034611	1842	+ 2	48.968	1.866488	3.042579
1845	+ 2	36.680	1.833693	3.009784	1845	+ 2	39.753	1.842125	3.018216
1850	+ 2	21.322	1.78888	2.96497	1850	+ 2	24.394	1.79822	2.97431
1855	+ 2	5.962	1.73890	2.91499	1855	+ 2	9.035	1.74936	2.92545
1860	+ 1	50.603	1.68241	2.85850	1860	+ 1	53.675	1.69431	2.87040
1864	+ 1	38.315	1.63126	2.80735	1864	+ 1	41.388	1.64462	2.82071
1865	+ 1	35.243	1.61747	2.79356	1865	+ 1	38.316	1.63125	2.80734
1870	+ 1	19.882	1.54107	2.71716	1870	+ 1	22.955	1.55746	2.73355
1872	+ 1	13.738	1.50631	2.68240	1872	+ 1	16.811	1.52404	2.70013
1875	+ 1	4.521	1.44832	2.62441	1875	+ 1	7.593	1.40852	2.64461
1880	+ 0	49.160	1.33021	2.50630	1880	+ 0	52.232	1.35654	2.53263
1885	+ 0	33.798	1.16748	2.34357	1885	+ 0	36.871	1.20527	2.38136
1890	+ 0	18.436	0.90423	2.08032	1890	+ 0	21.508	0.97118	2.14727
1895	+ 0	3.073	0.12608	1.30217	1895	+ 0	6.145	0.42711	1.60320
1900	− 0	12.291	0.72813_n	1.93422_n	1900	− 0	9.218	0.60319_n	1.77928_n

m and n are Struve's constants for the epoch $\frac{1}{2}(t + t_0)$.

If α' and δ' represent the approximate place of the star for the epoch $\frac{1}{2}(t + t_0)$, we have for the formulæ to be used:

$$\alpha = \alpha_0 + [m^s(t - t_0)] + [n^s(t - t_0)] \sin \alpha' \operatorname{tg} \delta'$$
$$\delta = \delta_0 + [n''(t - t_0)] \cos \alpha'$$

GENERAL NOTES.

The Illustrations of Popular Astronomy.—It speaks well for the illustrations of POPULAR ASTRONOMY and those of *Astronomy and Astro-Physics* that a score of them should be asked for, to aid in the illustration of a new book on astronomy that is now in the course of preparation.

The Gilliss Chile Catalogue of Stars forms a part of the volume of the Washington Observations for the year 1890. Professor William Harkness, astronomical director of the Naval Observatory says in a letter under date of March 7 that, "The entire volume was completely set up and stereotyped last fall but, thus far the Government Printing Office has been unable to print it on account of press of work considered more important."

Professor Harkness expresses the hope that the volume for 1890 will be printed soon. Other astronomers share in this hope.

Sad News from the Brashear Family.—We were greatly pained to learn by private letter from J. A. Brashear of Allegheny, recently, of the illness and death of Charles A. Brashear, having typhoid fever of malignant type. His protracted illness of 31 days, during which time J. A. Brashear himself became ill, was also a burden all too heavy for Mrs. Brashear. As ills never come singly, her sad lot was, by falling, to break bones of one of her limbs, so that she became helpless and seriously sick. The many friends of Mr. Brashear will readily see what a season of darkness and trial the Brashear family has passed through, and will realize what the loss of Mr. Charles A. Brashear to the firm and family means when it is known that he was a responsible associate in the managment of the large optical work now being conducted by Mr. J. A. Brashear. The Brashear family have the sincere sympathy of their large circle of friends everywhere.

Mars' Atmosphere.—We hasten to give place to an important communication from Professor W. W. Campbell, Lick Observatory, in regard to an editorial note relating to the atmosphere of Mars. That note was made on information supposed to be trustworthy and which fairly implied recent work of M. Janssen. From Professor Campbell's statement we seem to have been wrong. He says:

"The concluding editorial note in the December POPULAR ASTRONOMY refers to my observations of the spectrum of Mars, and concludes with the statement, 'Now it turns out that M. Janssen has recently informed the French Academy of Sciences that he has determined the existence of water vapor in the planet Mars by means of the spectroscope.'

Your editorial was misleading at first to me, and I fear it has been to others. M. Janssen's observations to the results of which your editorial refers, were made on Mt. Etna in the year 1867, more than twenty-eight years ago; and he communicated his results to the French Academy of Sciences in the year 1867, as follows: "* * I believe I can announce to you the presence of aqueous vapor, in the atmospheres of Mars and Saturn." [See *Comptes Rendus* for 1867, Vol. LXIV, p. 1304.]

I called attention to M. Janssen's observations in my original paper on "The Spectrum of Mars," quoting his results in full. [See *Publications A. S. P.*, Vol. VI, p. 229; also, *A.* and *A.-P.*, for November, 1894, p 753]. Further, I reviewed all the observations of Mars' spectrum, including M. Janssen's, in the *Astrophysical Journal* for June, 1895, page 39. It was in reply to my request for further details of his 1867 observations that M. Janssen published a note concerning them in *Comptes Rendus* for 1895, July 29; evidently the note to which your editorial refers.

M. Janssen stated that his observations were made May 12 to 15, 1867. Perhaps we may call attention to the fact that the diameter of Mars was then less than six seconds of arc, or about one fourth its diameter at favorable opposition. We are not informed as to the apparatus which was carried up Mt. Etna

for making the observations, but the telescope was probably comparable with a 6-inch refractor. In brightness and width the spectrum would not be very unlike that of a bright star.

The question of Mars' atmosphere and its constituents has an intensely popular side, and an intensely unpopular side. It happens that my observations led me to a middle-ground conclusion; but since they did not prove the existence of an atmosphere containing water vapor, they are generally misunderstood to favor the absolute non-existence of those elements. Such, however, is not the case. In my original paper I stated that the polar caps are conclusive evidence of atmosphere and vapor on Mars, but concluded that they are not sufficiently extensive to have been detected by spectroscopic observations thus far made. They may be detected at some future time—I hope they will. If they are, I am confident that the Martian atmosphere will not be more than one-fourth as extensive as our terrestrial atmosphere—that is, that its density at the surface of the planet will not be *more* than about half the density of the atmosphere at the summit of the highest peak in the Himalaya mountains. At least, such is the conclusion which I drew from my observations at the time they were made.

In view of the rapidly approaching opposition of Mars, I again call the attention of spectroscopists to the desirability of photographing the spectrum in the region of the telluric bands. All previous photography has been confined to the blue and violet regions, in which there are no known telluric bands. There are plates very sensitive to light from the region of the important δ band, and long exposures would record the spectrum at least as far as the band at λ 5950. If the Martian and Lunar spectra are photographically compared under identical and favorable circumstances, I think we may hope to obtain valuable results. At least, that should be the the objective point of the next spectroscopic observations of the planet. I obtained some photographs of the δ region in March, 1895; but all the conditions were somewhat unfavorable, and the results were indecisive.

W. W. CAMPBELL.

Mt. Hamilton, Cal.

Professor F. P. Leavenworth, of the University of Minnesota is to be congratulated on the installation of his new combination visual and photographic telescope of 10½ inches aperture, made by Warner & Swasey. Brashear made all the optical parts. We hope to visit Professor Leavenworth soon, for we learn that his telescope represents the highest type of telescope design and construction.

The Emerson McMillan Observatory, University of Ohio.—The new 12½ inch equatorial for the Emerson, McMillan Observatory, University of Ohio, has been placed in position by the makers, Messrs. Warner & Swasey. J. A. Brashear made the optical parts and also the spectroscope. This instrument is, both optically and mechanically, one of the finest ever constructed, and we heartily congratulate Professor Lord on the splendid facilities he has for doing the best work.

New Astronomical Instruments by Mr. Saegmuller.—By recent letter from Mr. Saegmuller, of Washington, D. C., we learn that he has completed a 9-inch photographic transit-instrument with collimators for the Observatory of Georgetown College; that a 4½-inch meridian circle has been finished for the Observatory of the Catholic University of America, and that a photographic equatorial, a combined transit and zenith telescope, position micrometer, and a chronograph are now in process of construction for Dr. Thome director of the Observatory at Cordoba, Argentine Republic, South America.

The private Observatory of L. Hubbard, Esq., at South Bend, Indiana, has ordered of Mr. Saegmuller, a 7-inch equatorial, a transit, a clock and a chronograph. Four other equatorials are also being constructed by him whose apertures range from 5 to 9 inches. (See Mr. Saegmuller's new advertisement).

The Ohio Wesleyan University of Delaware, Ohio, is building a splendid Observatory, designed by Architect Badgley of Cleveland. Warner & Swasey have been awarded the contract for the instrumental outfit, which includes an equatorial of 9½ inches aperture. Brashear is making the optical parts.

Professor E. L. Brown, of Capital University, Columbus, Ohio, has awakened so much interest, in the study of Astronomy, in the minds of his students, that they have raised nearly money enough to secure a 4½-inch telescope. Such a telescope will be of great service to teacher and student in effective, united work that will last in the minds of the young people.

Observations of Mira (Continued).—The gleam of this stellar visitor sparkling visibly down from a usually starless area, as if some swirl from "the dark unfathomed caves of ocean" had temporarily gemmed the marine monster, is in truth sent forth from the deeps of the ocean of ether, theoretically supposed to submerge the visible universe. Perhaps that when the mythological outline was first named, the visibility of the variable supplied the much needed link, which on these nights renders the form of the whole less unsatisfactory than usual.

Mira was probably at its maximum from January 21st to February 2d as it continued distinctly brighter than Delta Ceti, though about one-quarter of a magnitude less bright than Gamma Ceti.

On Feb. 3rd a decrease, on the 5th an increase, and then for two weeks a very gradual decrease was observed. Feb. 19th it was barely brighter than Delta, and if it continues to diminish at the same slow pace, its decline to invisibility will be lost in the twilight as during last year. ROSE O'HALLORAN.

San Francisco, Feb. 21st, 1896.

BOOK NOTICES.

Plane and Solid Geometry by W. W. Beman and D. E. Smith. Messrs. Ginn & Company have recently published a Plane and Solid Geometry by Professor W. W. Beman of the University of Michigan and D. E. Smith, Professor of Mathematics in the State Normal School at Ypsilanti. This book is receiving considerable attention, and, with reason, for its plan has been worked out thoroughly in detail by two teachers who well represent instructors of the classes of students for which this book is intended. Teachers will be interested in the matter, method of oral and written work and the general arrangement of the text.

Logarithmic and Trigonometric Tables by Edward A. Bowser, LL. D., Professor of Mathematics at Rutgus College.

Professor Bowser has prepared a first rate book of five place tables. The arrangement of the figures on the page are in groups of 3's instead of 5's which is an improvement over the ordinary way. Every tenth horizontal line has rules above and below which is both a help and a relief to the eye of the computer. The figures are clear, large enough and openly arranged so that the computer will easily find what he wants. Messrs. D. C. Heath & Co., 355 Wabash Ave., Chicago, are publishers.